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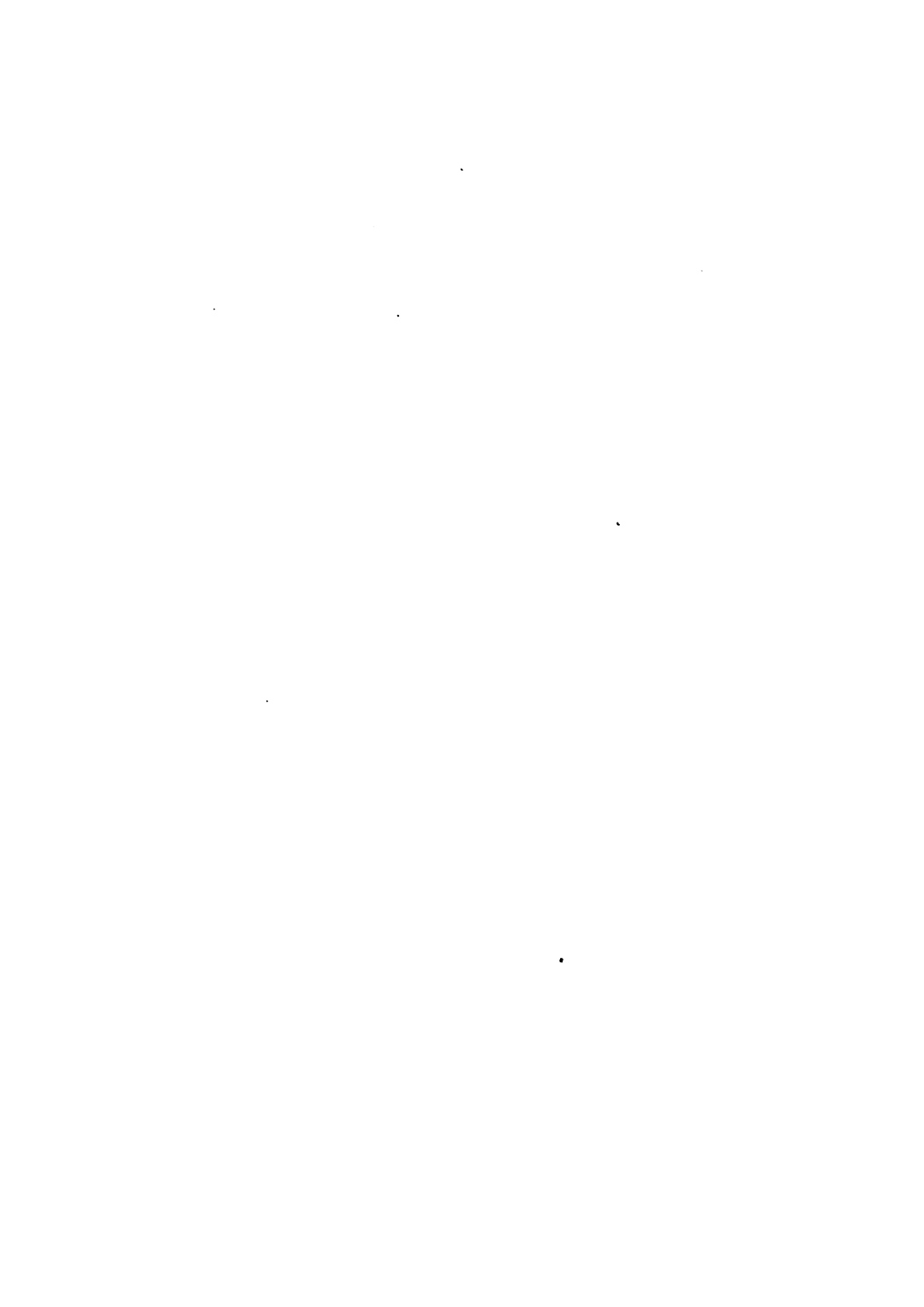
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P R E F A C E.

THE object of this work is to serve as an Introduction to the larger works by the Author upon the same subject.

The same general plan has been followed as in the 'Advanced Text-Book'—that is to say, more space has been devoted to the Invertebrate Animals than has usually been the case in Introductory works on Zoology. As a result of this, it will perhaps appear to some that comparatively scanty justice has been done to the Vertebrata. It is to be remembered, however, that the Vertebrate Animals are of no greater *zoological* value or interest than any other of the primary divisions of the Animal Kingdom; and the limits of this work peremptorily forbid the introduction of anything beyond purely scientific matter, if each sub-kingdom is to receive its proper quota of description.

The style of the work has been as entirely freed from technicalities as possible, and most of those subjects have been omitted which require a previous acquaintance with the elements of Physiology, since the work is intended to be nothing more than an Introduction to Systematic Zoology.

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Z O O L O G Y.



INTRODUCTION.

ALL natural objects may be divided roughly into two great sections, the one comprising all those bodies which are dead or are destitute of life ; whilst the other includes all those bodies which exhibit "life" or "vitality." The term "life" is merely employed as a collective expression to designate a group of phenomena which we observe in some of the natural objects around us, but which are absent in others. All the bodies which exhibit the phenomena in question are living, those which do not are dead ; and, as a rule, the distinction between dead and living bodies is an easy one. In some cases, however, we meet with bodies which are dead, and yet come under the province of the observer of living beings ; and in other cases we meet with objects which are really alive, but which nevertheless do not manifest any external vital phenomena. Thus, the objects known as "fossils" or "petrifications" are truly dead, but they are the remains of extinct living beings, and therefore properly belong to the student of this department of nature. Again, the seeds of plants and the eggs of animals are truly alive, in spite of the fact that they do not exhibit any manifest phenomena of vitality. Their vitality is dormant or *potential*, and not active ; but that they are really alive is shown by their power of exhibiting vital phenomena when placed under favourable conditions—a power not found in any bodies which are truly dead.

The first and grand characteristic by which living bodies may be distinguished from dead bodies, is the power possessed by the former of taking into their interior certain foreign materials and converting them into the substances required to build

fresh tissue or to repair waste. By this power of "assimilation," as it is called, a living body *grows*, or, if it has attained its full size, it maintains its regular condition, and replaces all inevitable losses. No dead body possesses this power of assimilating foreign materials, and by this point alone a living body can always be distinguished from a dead one. There are certain cases, however, in which dead bodies do actually increase in size, and might therefore, in a certain sense, be said to "grow." This, for instance, is the case with crystals; but the process cannot properly be said to be one of growth. Here there is no "assimilation" of foreign matter, nor are the materials to be incorporated first taken into the interior of the body. On the contrary, a crystal simply increases in size by the addition of fresh particles from the outside, and the particles thus added undergo no alteration in their composition or nature.

Secondly, living bodies, as they are constantly assimilating fresh matter, are incessantly losing portions of their substance; or, in other words, partial death is a constant accompaniment of life. In this way there is kept up in every living body a constant series of changes and vicissitudes, which are absent in all dead bodies alike.

Thirdly, if our observation be continued for a sufficient length of time, we invariably discover that every living body has the power, by more or less complex processes, of reproducing its like. That is to say, every living body has, directly or indirectly, the power of giving origin to minute germs, which are developed into the likeness of the parent; whilst the production of the germ, as a general rule, is not attended with any appreciable alteration in the producing body.

Fourthly, dead bodies are subject to the various physical and chemical forces of the universe, but have no power of suspending these laws, even for a temporary period. The matter of a living body is also subject to the same physical and chemical forces; but it is further the seat of something in virtue of which the living body can override the physical laws which enslave mere dead matter. The living body, so long as it *is* a living body, is the seat of *energy*, and can overcome the primary law of the *inertia* of matter. It has certain relations with the outer world other than the merely passive ones of dead matter. However humble it may be, and even if it be permanently rooted to one place, some part or other of every living body possesses the power of spontaneous and independent motion—a power possessed by nothing that is dead. In the higher animals the relations of the living body to dead nature become still further

complicated, and their mastery over the physical forces becomes more and more pronounced, till in man, whose complex organisation is wielded by an undying intelligence, we have a being in whose hands the dead matter of the universe is as obedient as plastic wax.

The above are the leading characters of living beings, and the study of such bodies is known by the general name of *Biology* (Gr. *bios*, life; and *logos*, discourse). Living bodies, however, may be divided into two great groups or kingdoms—the vegetable and the animal; and in like manner, Biology is divided into the two sciences of *Botany*, which treats of plants, and *Zoology* (Gr. *zoön*, animal; *logos*, discourse), which treats of animals. The term Natural History, again, is nowadays generally understood as being equivalent to Zoology alone, though originally it was applied indiscriminately to the study of all natural objects alike.

All living beings, as just remarked, may be divided into the two great kingdoms of plants and animals; but it is often an extremely difficult point to decide whether a particular organism is a vegetable or an animal. The higher animals are readily separated from the higher plants by the possession of a distinct nervous system; of locomotive power, which can be voluntarily exercised; and of an internal cavity, fitted for the reception and digestion of solid food. The higher plants, on the other hand, possess no nervous system or organs of sense, are incapable of voluntary change of place, and are not provided with any definite internal cavity, their food being wholly fluid or gaseous. It is unnecessary to enter into this question further at present; but it is to be remembered that these distinctions fail us when we come to discriminate between the lower forms of animal and vegetable life, and that in this case we are compelled to fall back upon other minuter differences.

It only remains to add that all living beings alike appear to be primitively composed of a substance which is more or less closely allied to *albumen*, or white-of-egg, and which has been termed "protoplasm," or "bioplasm." Vital phenomena can apparently be manifested by no other form of matter, and protoplasm bears to life the same relation that a conductor does to the electric current. It is the necessary vehicle and medium through which life is brought into relation with the external world. There is, however, as yet, no reason to believe that protoplasmic matter holds any other or higher relation to life, and that vital phenomena are in any way an inherent property of the matter by which they are manifested.

Lastly, the great majority of living beings are *organised*—that is to say, they are composed of different parts, or *organs*, which hold certain relations with one another, and which discharge different functions. It is not the case, however, that organisation is a *necessary* accompaniment of vitality, or that *all* living beings are organised. Many of the lower forms of life exhibit absolutely no structure, and cannot, therefore, be said to be “organised”; but they nevertheless discharge all their vital functions just as well as if they possessed special organs set apart for the performance of each. Animals, therefore, are organised, or possess structure, because they are alive; they do not live because they are organised.

CLASSIFICATION.

Classification is the arrangement of a number of dissimilar objects of any kind into larger or smaller groups, according as they exhibit more or less likeness to one another. The number of animals is so great that it would be wholly impossible to acquire any clear knowledge of them, unless some classification of them into groups were to be adopted. In arriving at such a classification naturalists compare animals with one another from two points of view. In the first place, they examine the laws, form, and arrangement of the *structures* of the organism. This constitutes the science of “Morphology,” or the science of form (from the Greek words *morphé*, form or shape; and *logos*, a discourse). In the second place, they examine the *physiological* differences between animals—that is to say, they examine and compare the different ways in which different animals carry on their vital functions. All animals differ from one another either *morphologically*, in the fundamental plan upon which they are constructed, or *physiologically*, in the way in which they discharge their vital functions, or both morphologically and physiologically. By careful examination and comparison of these differences, naturalists have succeeded in dividing the entire animal kingdom into a number of divisions, the general arrangement of which may be very briefly indicated. Firstly, the whole animal kingdom may be divided into two great sections, known respectively as “Invertebrate Animals” or *Invertebrata*, and “Vertebrate Animals” or *Vertebrata*. The leading characters which distinguish these two great sections are exhibited in the subjoined diagram, and may be shortly stated as follows: In all Invertebrate animals, the body, if divided transversely or cut in two, shows only a single tube containing all

the vital organs (fig. 1, A). These organs in the higher *Invertebrata* consist of a digestive or alimentary tube; a circulatory system, by which the vital fluids are distributed through the body; and a nervous system, by which the animal is brought into relation with the outer world. Any or all of these vital organs, however, may be wanting, or may be imperfect or rudimentary. When there is any skeleton, this is *external*, and is really nothing more than a hardening of the skin, produced by the deposition in it of horny matter, of lime, or of flint. The limbs, when present, are turned towards that side of the body upon which the main portions of the nervous system are situated.

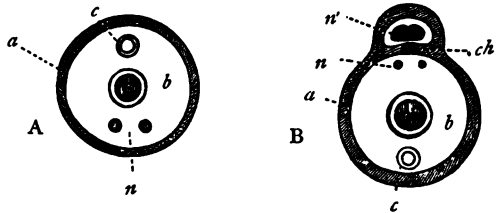


Fig. 1.—A, Diagrammatic section of one of the higher *Invertebrata*. B, Section of one of the *Vertebrata* (slightly altered from Huxley): *a* Wall of the body; *b* Alimentary canal; *c* Circulatory system; *n* Nervous system; *n'* Brain and spinal cord of the *Vertebrata*, enclosed in a separate tube; *ch* Notochord or chorda dorsalis.

In the *Vertebrata*, on the other hand, the body, if transversely divided, exhibits *two* tubes (fig. 1, B). In the one is placed the main mass of the nervous system (the brain and spinal cord). In the other tube are the alimentary canal, the main organs of the circulatory system, and certain other portions of the nervous system, which are known as the "sympathetic" system of nerves, and which correspond to the entire nervous system of Invertebrate animals. Further, in the *Vertebrata* there is always an *internal* skeleton, the central stem of which is usually constituted by a true backbone or "vertebral column." When this is not present, there is a structure, which will be afterwards described as the "notochord" or "chorda dorsalis." Lastly, the limbs of Vertebrate animals, when present, are never more than four in number, and they are always turned away from that side of the body on which the main masses of the nervous system are placed.

The subdivision of the Invertebrate animals is divided into five great groups or "morphological types," which are known

as *sub-kingdoms*. These primary types of structure are known to naturalists under the technical names of the *Protozoa*, *Cœlenterata*, *Annuloida*, *Annulosa*, and *Mollusca*. Their distinguishing characters and more important subdivisions will be spoken of hereafter, and need not, therefore, be noticed here. The division of the Vertebrate animals constitutes by itself a sixth sub-kingdom, which is simply known under the name of *Vertebrata*. There are, therefore, *six* primary types of structure or sub-kingdoms, to one or other of which all known animals may be referred. The highest of these forms alone the division of the "Vertebrate Animals," whilst the five lower sub-kingdoms are grouped together under the collective name of "Invertebrate Animals."

Subjoined is a short tabular view of the main existing divisions of the animal kingdom, the characters of which will be considered hereafter :—

INVERTEBRATE ANIMALS.

SUB-KINGDOM I.—PROTOZOA.

- Class 1. Gregarinida.*—*Ex.* Gregarina.
- Class 2. Rhizopoda.*—*Ex.* Amœba, Sponges.
- Class 3. Infusoria.*—*Ex.* Paramœcium, Bell-animalcule.

SUB-KINGDOM II.—CÆLENTERATA.

- Class 1. Hydrozoa.*—*Ex.* Fresh-water Polypes, Sea-firs, Sea-jellies, Portuguese Man-of-War.
- Class 2. Actinozoa.*—*Ex.* Sea-anemones, Corals, Sea-pens.

SUB-KINGDOM III.—ANNULOIDA.

- Class 1. Echinodermata.*—*Ex.* Sea-urchins, Star-fishes.
- Class 2. Scolecida.*—*Ex.* Tape-worms, Round-worms, Wheel-animalcules.

SUB-KINGDOM IV.—ANNULOSA.

- Class 1. Gephyrea.*—*Ex.* Spoon-worms.
- Class 2. Annelida.*—*Ex.* Leeches, Earth-worms.
- Class 3. Chaetognatha.*—*Ex.* Sagitta.
- Class 4. Crustacea.*—*Ex.* Crabs, Lobsters, Acorn-shells.
- Class 5. Arachnida.*—*Ex.* Spiders, Scorpions, Mites.
- Class 6. Myriapoda.*—*Ex.* Centipedes, Millipedes.
- Class 7. Insecta.*—*Ex.* Beetles, Butterflies, Bees.

SUB-KINGDOM V.—MOLLUSCA.

- Class 1. Polynoa.*—*Ex.* Sea-mosses, Sea-mats.
- Class 2. Tunicata.*—*Ex.* Sea-squirts.
- Class 3. Brachiopoda.*—*Ex.* Lamp-shells.
- Class 4. Lamellibranchiata.*—*Ex.* Oysters, Mussels, Cockles.
- Class 5. Gasteropoda.*—*Ex.* Whelks, Limpets, Snails.
- Class 6. Pteropoda.*—*Ex.* Clio, Cleodora.
- Class 7. Cephalopoda.*—*Ex.* Cuttle-fishes, Nautilus.

VERTEBRATE ANIMALS.

SUB-KINGDOM VI.—VERTEBRATA.

Class I.—Pisces (Fishes).

- Order a. Pharyngobranchii.—*Ex.* Lancelet.
- Order b. Marsipobranchii.—*Ex.* Lamprey.
- Order c. Teleostei.—*Ex.* Cod, Salmon.
- Order d. Ganoidei.—*Ex.* Bony-pike, Sturgeon.
- Order e. Elasmobranchii.—*Ex.* Sharks, Rays.
- Order f. Dipnoi.—*Ex.* Mud-fish.

Class II.—Amphibia (Amphibians).

- Order a. Ophiomorpha.—*Ex.* Cæcilia.
- Order b. Urodela.—*Ex.* Newts.
- Order c. Anoura.—*Ex.* Frogs and Toads.

Class III.—Reptilia (Reptiles).

- Order a. Chelonia.—*Ex.* Tortoises and Turtles.
- Order b. Ophidia.—*Ex.* Snakes.
- Order c. Lacertilia.—*Ex.* Lizards and Blind-worms.
- Order d. Crocodilia.—*Ex.* Alligators.

Class IV.—Aves (Birds).

- Order a. Natatores.—*Ex.* Ducks and Geese.
- Order b. Grallatores.—*Ex.* Curlews, Herons.
- Order c. Cursores.—*Ex.* Ostrich, Emeu.
- Order d. Rasores.—*Ex.* Fowls, Pheasant, Doves.
- Order e. Scansores.—*Ex.* Parrots and Woodpeckers.
- Order f. Insesores.—*Ex.* Crows, Larks, Finches.
- Order g. Raptores.—*Ex.* Hawks, Owls, Vultures.

Class V.—Mammalia (Mammals).

- Order a. Monotremata.—*Ex.* Duck-mole, Echidna.
- Order b. Marsupialia.—*Ex.* Kangaroos, Opossums.
- Order c. Edentata.—*Ex.* Sloths, Ant-eaters, Armadillos.
- Order d. Sirenia.—*Ex.* Dugong, Manatee.

- Order e. Cetacea.—*Ex.* Whales, Dolphins.
Order f. Ungulata.—*Ex.* Rhinoceros, Hippopotamus, Pigs,
Sheep, Oxen, Antelopes.
Order g. Hyracoidea.—*Ex.* Hyrax.
Order h. Proboscidea.—*Ex.* Elephant.
Order i. Carnivora.—*Ex.* Seals, Lion, Dog, Bear.
Order j. Rodentia.—*Ex.* Beaver, Rats, Mice, Squirrels.
Order k. Cheiroptera.—*Ex.* Bats.
Order l. Insectivora.—*Ex.* Hedgehogs, Moles.
Order m. Quadrumana.—*Ex.* Apes, Baboons.
Order n. Bimana.—(Man.)

INVERTEBRATE ANIMALS.



SUB-KINGDOM I.—PROTOZOA.

CHAPTER I.

THE sub-kingdom *Protozoa* (Gr. *protos*, first; *zoön*, animal), as the name implies, is the lowest division of the animal kingdom, and comprises a vast number of organisms, most of which are only visible to the microscope, and are therefore not familiar to the majority of people. Some few, however, such as the sponges, form colonies, which often attain a comparatively gigantic size. From their low position in the animal scale, it arises that the *Protozoa* are mainly characterised by the absence of organs and structures which occur in higher beings, and they possess few positive characters by which they can be distinguished.

The most important common character of the *Protozoa* is the nature of the substance of which their bodies are composed. This is generally called "sarcode" (Gr. *sarx*, flesh; *eidos*, form), and is a gelatinous substance very like white-of-egg, and really of nearly the same chemical composition, since it consists essentially of some body allied to albumen. It has, however, numerous minute oil-globules generally scattered through it. The sarcode possesses the physiological property of "contractility"—that is to say, it may be made to contract or shorten its dimensions, thus giving rise to movements. As a rule, no other structures appear in the sarcode beyond minute solid particles or granules, but in some cases definite structures are formed out of it.

In internal structure all the *Protozoa* exhibit the greatest simplicity. In no case does the sarcode of the body exhibit any division into definite segments, or parts which have definite

relations to one another. Often there is nothing whatever which can be called *structure*, the whole body being simply composed of sarcode with scattered granules. In other cases, there are found certain definite bodies which are known as the "nucleus" and "nucleolus," and which are usually, if not always, connected with reproduction. Very often, too, there are minute chambers which expand and close at regular intervals, and which are called "contractile vesicles." These may be regarded as probably representing the circulatory organs of higher animals. Only in the highest forms (*Infusoria*) is there certainly known to be any permanent mouth, and in none is there any definite body-cavity or distinct digestive cavity of any kind; in other words, the outer walls of the body of all the *Protozoa* do not enclose any definite chamber or cavity, but are simply filled with soft semi-fluid sarcode. There are no traces of any nervous system, nor are there any organs of sense—that is to say, there are no definite organs fitted for the reception of the impressions produced by light and sound.

The *Protozoa* may be divided into three great divisions or "classes," known by the names of *Gregarinida*, *Rhizopoda*, and *Infusoria*, and all of these require more or less attention.

CLASS I. GREGARINIDÆ.—The *Gregarinida* differ from all the other members of the *Protozoa* in being *parasitic*—that is to say, in living in the interior of other animals, in place of leading an independent existence. They possess no mouth, and they have no power of throwing out the temporary processes of sarcode (*pseudopodia*) which form the characteristic organs of locomotion of the class of the *Rhizopoda*. They vary in size from less than the head of a small pin up to nearly half an inch, when they look like little worms; and they are found inhabiting the intestines of various animals, especially the cockroach and the earth-worm.

In anatomical structure a *Gregarina* (fig. 2, *a*) usually presents the appearance of what anatomists call a "cell." It consists, namely, of an outer ill-defined membranous envelope, filled with a more or less granular sarcode containing fatty granules, and having in its interior a little bladder—the "nucleus"—which, in turn, encloses a solid particle or "nucleolus."

In its reproduction, the *Gregarina* shows some singular phenomena. A single individual, or two individuals which have come together and completely melted into one another, surrounds itself with a thick coat or envelope, assumes a globular

form, and becomes motionless, when it is said to be "encysted" (fig. 2, *b*). It now develops in its interior little bodies, which

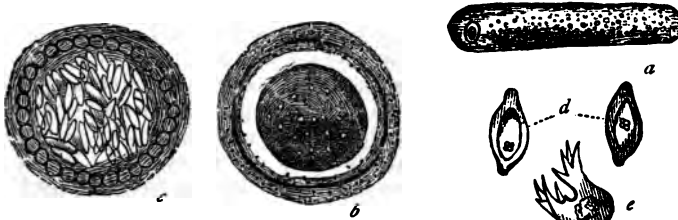


Fig. 2.—Anatomy and reproduction of the Gregarina of the earth-worm. *a* Adult Gregarina; *b* The same "encysted"; *c* The same with the contents broken up into "pseudonavicellæ"; *d* Free pseudonavicellæ; *e* Contents of these when liberated.

are pointed at both ends, and which are called "pseudonavicellæ," from their resemblance in shape to a little fresh-water plant, the *Navicula*. These little bodies (fig. 2, *d*) are then liberated by the rupture of the cyst, and give origin to little masses of sarcode (fig. 2, *e*), which move about actively by means of temporary processes of their substance, and are ultimately developed into new *Gregarina*.

CLASS II. RHIZOPODA.—This class of the *Protozoa* comprises the most characteristic and typical forms of the whole subkingdom, and derives its name of *Rhizopoda* (Gr. *rhiza*, root; and *pous*, foot), or "root-footed" animalcules, from the fact that they all possess the power of throwing out temporary processes of the body-substance, which they employ in moving about and in obtaining food. These processes can be thrown out from a part or the whole of the surface of the body, and they are termed "pseudopodia," from the Greek words *pseudos*, false, and *pous*, a foot. This name is given them because they are not permanent organs like the feet of the higher animals, but can be produced at will, and can be withdrawn again into the substance of the body, into which they melt, without leaving a trace behind.

As types or examples of the *Rhizopoda*, we may briefly consider the *Amæba*, or Proteus-animalcule, the so-called *Foraminifera*, and the Sponges.

The *Amæba* (Gr. *amœbos*, changing) derives both its scientific and its common name from the endless changes of form which it exhibits (fig. 3, *a*). It can be obtained for examination either

from the waters of stagnant pools, or simply by exposing to light and warmth a little water in which any animal or vegetable substance has been soaked. The *Amæba* is invisible to the unassisted eye, but appears under the microscope as a little lump of transparent jelly, containing a few solid particles or granules, with larger clear spaces, and generally a single oval body, or "nucleus," of some size in its interior. As the animal is watched, it will be seen to push out a portion of its substance in the form of a blunt finger-like process or processes in some particular direction. This pushing out of prolongations of sarcodæ or pseudopodia can be effected from almost every part of the body; and the processes themselves assume such diverse shapes that the figure of the animal, when active, is hardly the same for any length of time together. They serve the purpose of feet, and by their means the *Amæba* creeps about with tolerable facility. In fact, it might almost be said, without exaggeration, that the animal appears to *flow* in any direction it may wish, much as a drop of any viscous fluid would behave if placed upon a glass slide, the level of which was constantly

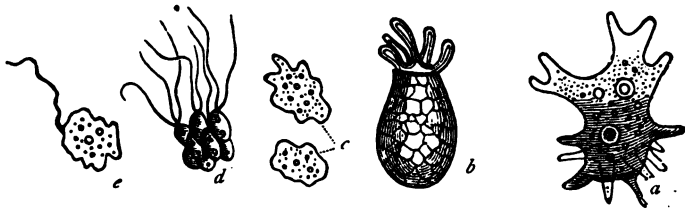


Fig. 3.—Morphology of Rhizopoda. *a* *Amæba*, showing the pseudopodia, the contractile vesicle, and the nucleus; *b* *Diffugia*; *c* Detached sponge-particles; *d* Sponge-particles of *Grantia*, each carrying a single filament or "cilium"; *e* Sponge-particle of *Spongilla*, with a single cilium. All greatly magnified.

being altered. When withdrawn, the pseudopodia simply melt into the substance of the body. By means of these extemporised feet the *Amæba* not only changes its place, but also obtains its food. When it comes into contact with any nutritive particle, it wraps a temporary arm around it, and drags it into the interior of the body, to be digested if possible, but if not, to be rejected by a similar but reversed action. There is no permanent mouth therefore; but in this convenient manner almost any part of the surface of the body can be made to do duty as a temporary mouth. There is no digestive cavity or stomach; there are no breathing-organs; there are no organs of the senses; nor is there a nervous system; and there is only a doubtful

rudiment of the circulatory system, in the form of a "contractile vesicle." This is a little chamber which expands and contracts at regular intervals, driving the fluid contained in it through the body. The contained fluid is usually said to be derived from the digestion of the food, in which case it would correspond to the blood, and the chamber itself would correspond to the heart, of the higher animals. It is stated, however, that radiating tubes have been seen proceeding from the contractile vesicle, and that these communicate with the exterior. In this case the fluid contained in the vesicle will only be water, and it would correspond with what will afterwards be described as the "water-vascular system." Lastly, the *Amæba* possesses an oval solid body, the "nucleus," which is probably connected with reproduction, but there are no other internal organs of any kind. The *Amæba* appears to reproduce itself chiefly by a process of cleavage, or, as it is technically called, "fission" (Lat. *findo*, I cleave). In this process the body gradually divides or splits into two parts, each of which becomes a separate and independent individual. In other cases a fresh being may be produced simply by the casting off of a single pseudopodium.

Nearly allied to the *Amæba* is *Diffugia* (fig. 3, *b*), which occurs in both fresh and salt water. In its essential structure it agrees with the *Amæba*, but its body is enclosed in a little shell or case, mostly composed of grains of sand, cemented together. Within this case the animal can retire completely, but there is a single opening at one end, from which the thick and finger-like pseudopodia are emitted.

More interesting than the *Amæba* from every point of view are the minute shelled animalcules known as *Foraminifera* (fig. 4). The *Foraminifera* are almost all extremely minute, but they are better known than they would otherwise be, in consequence of the fact that they have the power of secreting a hard covering or shell—the "test"—which is composed either of carbonate of lime, or of particles of sand cemented together by some animal cement. For this reason, too, they exhibit a false kind of complexity of structure, for the shells are often very elaborate in their structure, and are usually exquisitely beautiful in their form. At first sight, therefore, we might imagine that the *Foraminifera* were of a very high grade of organisation; and for a long time, indeed, they were actually placed in the same class with the Pearly Nautilus, merely on account of the form of the shell. When we come, however, to examine the soft body contained within the shell, the eye, fortified by the splendid appliances of the modern microscope, fails to dis-

cover anything which could be called *structure* or *organisation*. The body of any one of the *Foraminifera* consists, in fact, of nothing more than jelly-like structureless sarcode, containing only a few microscopic particles or granules and oil-globules. Even the "nucleus" and "contractile vesicle" which we have seen in the *Amæba*, are wanting in the *Foraminifera*, and the sarcode-body is absolutely destitute of any internal organs of any kind. The *Foraminifera*, however, possess the power of giving out numerous pseudopodia or processes of their body-substance, which agree with those of the *Amæba* in serving for locomotion and for obtaining food. In this case, however, the pseudopodia differ altogether from the blunt and finger-shaped processes of the *Amæba*, since they are very long, attenuated, and thread-like, and interlace with one another towards their extremities (fig. 4, *b*, *c*), so as to form a network like "an animated spider's web" (Carpenter). Under high powers of the microscope, too, the pseudopodia show numerous minute

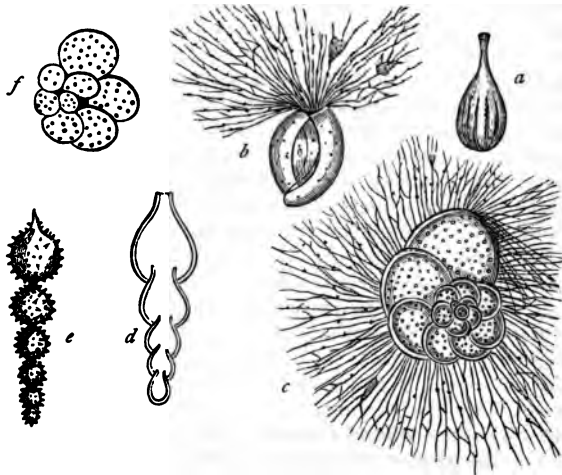


Fig. 4.—Morphology of the Foraminifera. *a* *Lagena*, having a single-chambered shell; *b* *Miliola* (after Schultze), showing the thread-like pseudopodia protruded from the mouth of the shell; *c* *Discorbina* (after Schultze), showing the many-chambered shell, with the pseudopodia protruded from the entire surface of the shell by minute apertures; *d* Section of *Nodosaria hispida* (after Carpenter), showing the chambers; *e* *Nodosaria hispida*; *f* *Globigerina bulloides*.

granules or solid particles which are in constant movement and circulation.

As the body of a Foraminifer is enclosed in a hard covering

or shell, the pseudopodia can only be emitted wherever the shell is absent, and here we come to an important distinction amongst the *Foraminifera*. In one group, the walls of the shell are not perforated by any holes, and consequently the pseudopodia can only be protruded from the mouth of the shell (fig. 4, *b*). These forms resemble *Diffugia* (fig. 3, *b*), except for the nature of the pseudopodia, and the fact that the shell usually consists of more than a single chamber. In another group, however, not only are the pseudopodia protruded from the mouth of the shell, but the entire shell is perforated by a number of minute holes, or "foramina," through which the filaments of sarcode are given out (fig. 4, *c*). From this circumstance the name *Foraminifera* has been itself derived (Lat. *foramen*, an aperture; and *fero*, I carry).

The simplest form of the *Foraminifera* is when the animal consists of but a single little mass of sarcode contained in a single-chambered shell. *Lagena* (fig. 4, *a*), with its beautiful flask-shaped shell, is an excellent illustration of this condition. All the *Foraminifera* commence life in this simple state, but this simplicity is often, indeed usually, lost before maturity is reached. In most cases, namely, the single original mass of sarcode throws out buds, each bud having the power of surrounding itself with an envelope of lime or sand. All the buds thus produced remain in connection with one another, and in this way are produced colonies or aggregations of little masses of sarcode, the whole assemblage being surrounded by a common shell. The separate chambers of the shell (fig. 4, *d*) are connected with one another by apertures, through which pass processes of sarcode, by which all the buds are united to one another. The form of the shell is extremely various in different cases, depending upon the direction in which the buds are successively thrown out. In one of the commonest forms the chambers are arranged in a straight line, as in *Nodosaria* (fig. 4, *e*); and in another, the segments are coiled up into a spiral, as in *Discorbina* (fig. 4, *c*). This last type of shell is the one which resembles the Pearly Nautilus in shape. In some cases, however, the new segments are added in a more or less irregular manner, as in *Globigerina* (fig. 4, *f*), and the resulting shell is much less beautiful in shape than in the preceding forms.

As regards the occurrence of *Foraminifera* at the present day, they are found in almost all seas, and sometimes in brackish waters. Two or three of the commoner forms may be detected on the fronds of the tangle at low water on our own coasts. In

many places, especially within the tropics, the sand of the sea-shore is to a great extent composed of the cast-away shells of these minute organisms. Thus, Plancus found 6000 in an ounce of sand from the Adriatic, and D'Orbigny found no less than three or four millions in an ounce of sand from the Caribbean Sea. Most of the *Foraminifera*, however, are only to be obtained by dredging in tolerably deep water, and they have been found to extend to the greatest depths in the ocean which have hitherto been examined by the dredge or the sounding-lead. Abundant remains of *Foraminifera* have been detected forming a kind of chalky substance or "ooze," at depths in the Atlantic of nearly 15,000 feet, or not far short of three miles. They appear, in fact, to abound in all seas and at all depths, where the water is sufficiently warm to permit of their existence.

The *Foraminifera*, lastly, are very important from a geological point of view, since they appear to be the oldest of created beings, and they likewise form in great part several well-known rock-formations. As an instance of this, it is sufficient to mention that the great formation of the White Chalk, which attains sometimes a thickness of no less than 600 feet, is almost entirely composed of the microscopic shells of *Foraminifera*.

Closely allied to the *Foraminifera* is a group of exquisitely beautiful little organisms, which are known as *Polycystina* (fig. 5, *b*). These are all microscopic in size, and they agree with

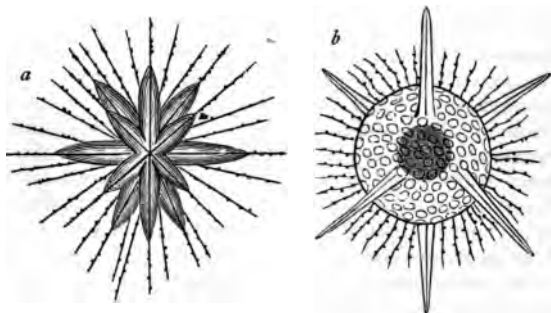


Fig. 5.—*a* *Acanthometra*; *b* *Halionma*, one of the *Polycystina*, showing the shell and the radiating pseudopodia. (After Müller.)

the *Foraminifera* in possessing a structureless sarcode-body, enclosed in a perforated shell, and capable of emitting numerous thread-like interlacing pseudopodia. They differ from the *Foraminifera* in the fact that the shell is always perforated with apertures for the pseudopodia, and that it is composed of flint.

The shells are therefore quite transparent and glassy, and they are usually of extreme beauty, being variously sculptured, and often adorned with spines. In other nearly-related forms, such as *Acanthometra* (fig. 5, *a*), the sarcode-body is not enclosed in a distinct shell, but is furnished with long radiating spines of flint.

The last of the *Rhizopoda* which require notice are the Sponges (*Spongida*), forming a singular group of organisms which were long believed to be plants, but are now almost universally regarded as animals. At first sight the Sponges appear to be extremely complicated, but we readily arrive at a conception of their true nature when we understand that a Sponge is not a single animal, but is a *colony* or aggregation of partially-independent beings. For our present purpose, in fact, we may regard a Sponge as being nothing more than a colony or assemblage of *Amæba*, which has the power of secreting for itself a hard framework or skeleton by which the whole structure is supported. If we take one of the common horny sponges of commerce, we find that it is composed of two distinct elements, the "skeleton" and the "sponge-flesh." What we buy as the sponge is not really the animal, but is nothing more than the *skeleton*, from which all the animal matter has been artificially removed. The skeleton of a horny Sponge (fig. 7, *d*) is composed of innumerable horny fibres, all inextricably interwoven and interlaced, so as to form a species of framework, which is perforated by numerous apertures and canals of different sizes. The skeleton is further strengthened by numerous needle-like bodies of various forms, which are termed "spicula," and which consist sometimes of flint and sometimes of lime. In certain Sponges the skeleton is entirely composed of spicules, which are composed of flint in the so-called "siliceous" sponges, and of lime in the "calcareous" sponges.

In any case, when the sponge is alive, the skeleton is entirely covered by the "sponge-flesh," which forms a gelatinous covering, resembling white-of-egg in texture, for every portion of the entire framework, both within and without. This "flesh" is truly the animal element of the sponge, and it is, of course, removed in the sponges which we employ. If, however, a portion of this slimy sponge-flesh be taken and placed under the microscope, it is found to be composed of a great number of minute masses of sarcode, all more or less completely independent of one another, and each very closely resembling the animalcule which has been already described as the *Amæba*. Each of these separate "sponge-particles," as they are called, can thrust

out little processes of sarcode, in the form of pseudopodia, and in some cases (fig. 3, *d*, *e*) each is furnished with a vibrating filament or "cilium." The sponge-particles obtain food by means of these processes of sarcode, just as we saw in the *Amœba*. The *Amœba*, however, is free, and can go in search of its food. The sponge-particles, on the other hand, are members of a community or colony, which they cannot leave; and for this reason some arrangement is necessary by which food may be brought to them without their going to look for it. This is effected in a very interesting manner by what is called the "aquiferous" or water-carrying system of the sponge. If a common sponge be

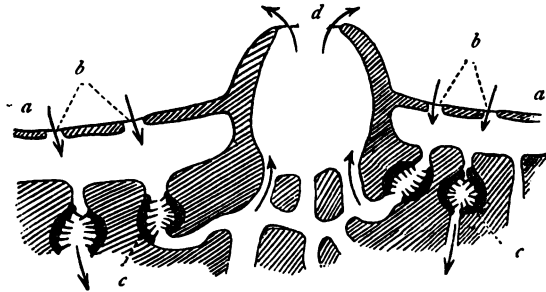


Fig. 6.—Diagrammatic section of *Spongilla* (after Huxley). *a a* Outer layer of the sponge; *b b* Inhalant apertures or "pores;" *c c* Ciliated chambers; *d* An exhalant aperture or "osculum."

examined, it will be at once seen that the surface exhibits two distinct sets of holes. The apertures of the one set are extremely minute and very numerous, and they are called the "inhalant apertures" or "pores." The other apertures are very much fewer in number and much larger in size, and they are called the "exhalant apertures" or "oscula." The large apertures or oscula are permanent, but they can be opened or closed at will; whilst the smaller apertures or pores appear to be formed afresh wherever they are required. If a sponge be examined in a living state, it is found that these apertures, and the canals which connect them, serve to maintain a constant and singular circulation of water through every portion of the sponge. The water is admitted by the smaller apertures or pores (fig. 6, *b*, *b*), circulates through the entire organism, and is expelled again in steady currents from the larger apertures or oscula. In this way particles of food are incessantly brought within the reach of every individual sponge-particle, and the

outgoing currents carry off with them all the useless matters which might otherwise accumulate injuriously within the organism. A sponge, in fact, may be compared to "a kind of sub-aqueous city, where the people are arranged about the streets and roads in such a manner that each can easily appropriate his food from the water as it passes along" (Huxley). The mechanism by which this circulation of water is maintained is found in certain chambers (fig. 6, *c, c*) in the interior of the sponge, which are lined with sponge-particles, each of which carries a single vibrating filament or "cilium" (fig. 3, *e*). By the lashing movement of these the water is driven into the deeper parts of the sponge.

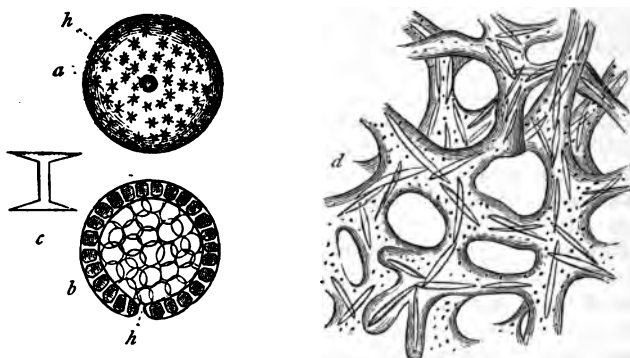


Fig. 7.—*a* Gemmule of *Spongilla*; *b* Diagrammatic section of the same; *c* One of the spicules in the outer covering of the gemmule; *d* Fragment of the skeleton of a horny sponge (after Bowerbank), showing the interlacing horny fibres with spicula. All much magnified.

Reproduction in the sponges appears to be carried on partly by means of eggs and sperm-cells, and partly non-sexually. In the common fresh-water sponge (*Spongilla*) eggs are produced in summer, and are fertilised by contact with sperm-cells. The resulting young or embryos are at first quite independent, swimming about freely by means of numerous little vibrating hair-like processes or "cilia." When they meet, however, with a suitable locality, they fix themselves, lose their cilia, and develop into new *Spongillæ*. Towards the approach of winter, on the other hand, the deeper portions of the fresh-water sponge are found to be filled with numerous little rounded bodies, which have been called "gemmules" (fig. 7, *a, b*). With-

in these gemmules are masses of cells, which are discharged into the water in spring, and are then developed into fresh individuals.

As regards their occurrence at the present day, all the sponges, with the exception of the single genus *Spongilla*, inhabit the sea; but the latter is found in lakes and rivers. The marine sponges are found mostly attached to stones and other foreign objects, between tide-marks or in deep water, but some are merely rooted in the sand. The sponges of commerce are chiefly obtained from the Grecian Archipelago, but inferior kinds are imported from the Bahama Islands.

CLASS III. INFUSORIA.—The last class of the *Protozoa* is that of the *Infusoria*, or so-called "Infusorian Animalcules." The animals included under this head are, without exception, microscopic in size, and they are found in countless numbers in all collections of stagnant water. They acquire their name of *Infusoria*, however, from their occurrence in another locality under the following singular circumstances: If, namely, a little water be taken in which any animal or vegetable substance has been soaked, we obtain what is called an "organic infusion"—namely a fluid containing organic matter in solution. If this fluid be boiled, so as to kill all living beings which may be contained in it, and be then allowed to stand for a few days, in a warm place, exposed to light, a great number of living organisms may be detected in it by means of the microscope. Amongst these will almost certainly be found some of the members of the present class, and hence the name applied to them.

Most of the *Infusoria* are free-swimming independent animals, but some of them form colonies by budding, and these present a striking resemblance to miniature plants. As a type of the former group may be taken *Paramæcium* (fig. 8), and of the latter, the pretty little Bell-animalcule or *Vorticella* (fig. 9, c). The two most important characters by which the *Infusoria* are distinguished as a whole from the other groups of the *Protozoa*, are the possession of a mouth and short gullet, and the inability to thrust out those temporary processes of sarcode which have been described under the name of pseudopodia, and are so characteristic of the *Rhizopoda*.

Paramæcium (fig. 8) presents itself in the form of a little melon- or slipper-shaped creature, almost perfectly transparent, and showing only a few dark granules and circular spaces. This is all that a first glance would reveal, but the observer

would be immediately struck with its great activity in the absence of any conspicuous organs of locomotion. Careful observation, however, soon shows that *Paramecium* owes its

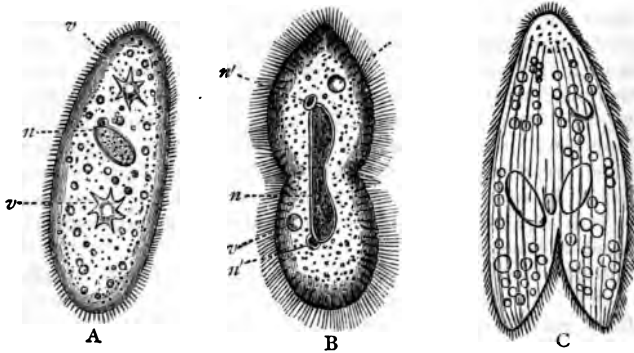


Fig. 8.—A, *Paramecium*, showing the nucleus (*n*) and two contractile vesicles (*v*); B, *Paramecium bursaria* (after Stein), dividing transversely; C, *Paramecium aurelia* (after Ehrenberg), dividing longitudinally.

power of changing its place to innumerable little microscopical filaments or hairs which are called "cilia" (Lat. *cilium*, an eye-lash). These cilia cover the entire surface of the body, and are in almost constant vibration, lashing to and fro with a speed too great to be followed by the eye, but being at the same time under the control of the animal. Not only does the animal move by means of the combined efforts of the innumerable cilia, but it likewise obtains food by the same agency. The cilia, namely, set up currents in the surrounding water, so that each *Paramecium* forms the centre, as it were, of a little whirlpool, and it is by means of these currents that particles of food are brought within the reach of the mouth. The mouth forms a distinct and permanent aperture, which conducts by a short funnel-shaped gullet, not into a distinct digestive cavity or stomach, but into a mass of soft semi-fluid sarcode which forms the centre of the body. This central mass is surrounded by a layer of more consistent and firmer sarcode, and this, in turn, is covered by a delicate transparent film or "cuticle," which forms the outermost layer of the body. The particles of food are directed into the soft sarcode filling the interior of the body, and here they undergo a sort of circulation or rotation. The particles of food are often surrounded each by a little drop of water, forming a clear circular space, and

the appearance thus produced formerly gave rise to the belief that the animal possessed a perfectly indefinite number of stomachs.

The only structures or internal organs possessed by *Paramæcium* are the "contractile vesicle" and the so-called "nucleus" and "nucleolus." The first of these is a little cavity exactly similar to what we have seen in the *Amœba*—that is to say, it is a little contractile chamber, which contracts and expands at regular intervals, and is filled with a colourless fluid. The "nucleus" is an oval solid body, which produces eggs, and is, therefore, really an ovary. The "nucleolus" is a minute spherical body, which is attached to the exterior of the nucleus, and is also reproductive in function, producing the spermatogenic element of generation.

Reproduction in *Paramæcium* may be effected by "fission"—that is to say, by a simple splitting of the body into two portions, each of which becomes a fresh being; or by the production of ova and sperm-cells, by the union of which young are produced.

The Bell-animalcule or *Vorticella* (fig. 9, *c*) may be found in any stagnant pool, attached to the stems of aquatic plants, and it forms an excellent example of those *Infusoria* which are permanently rooted and fixed to one spot in their adult condition.

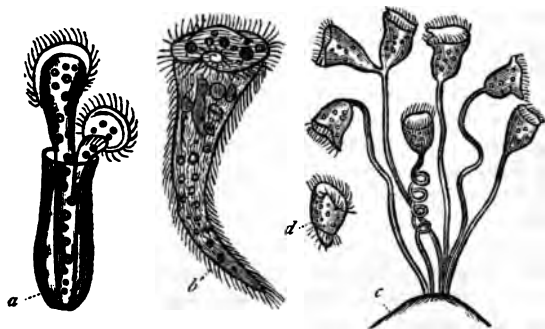


Fig. 9.—*a* *Vaginicola*; *b* *Stentor*; *c* Group of *Vorticella*;
d Detached bud of *Vorticella*.

The body in *Vorticella* forms a kind of cup or "calyx," supported upon a long stalk, which in turn is fixed to some solid object. The stem contains a contractile fibre in its interior, and the animal can by this means push itself out or coil itself up with

the utmost rapidity. The entire surface of the bell-shaped body is not covered with cilia, but these vibrating filaments are now collected so as to form a kind of fringe or ring round the upper margin or mouth of the bell. Nearly in the centre of this ring, or on one side, is placed the aperture of the mouth, which leads by a short gullet straight into the central soft sarcode of the interior of the body. A nucleus and contractile vesicle are also present, so that, in the essential points of its structure, *Vorticella* does not differ from a free-swimming Infusorian, such as *Paramecium*; indeed, a transition between the two forms is found in the so-called Trumpet-animalcule or *Stentor* (fig. 9, *b*), which can detach itself and swim about at will, at the same time that it is ordinarily fixed by its thinner extremity to some solid object. In *Vaginicola* (fig. 9, *a*), again, we have an animalcule closely allied to *Stentor*, but having the body protected by a membranous or horny sheath.

Paramecium and *Vorticella* both possess *cilia*, and they belong to a group of the *Infusoria* hence called "Ciliated." In other cases, however, in addition to the cilia, or in their absence, the animal has one or more long whip-like appendages or "flagella," by the lashing of which it moves about. These are the so-called "Flagellate" *Infusoria*. Lastly, in the "Suctorial" *Infusoria*, the body is furnished with numerous radiating filaments, the extremities of which form little sucking-discs.

TABLE SHOWING THE DIVISIONS OF THE PROTOZOA.

CLASS I. GREGARINIDÆ.—Parasitic Protozoa, which are destitute of a mouth, and do not possess the power of putting forth pseudopodia. *Ex. Gregarina.*

CLASS II. RHIZOPODA.—Protozoa which are destitute of a mouth, are simple or compound, and have the power of putting forth temporary processes of the body-substance (pseudopodia). *Ex. Amaba, Foraminifera, Polycystina, Spongida.*

CLASS III. INFUSORIA.—Protozoa with a mouth (in most cases, if not in all); destitute of the power of putting forth pseudopodia; furnished with vibratile cilia or contractile filaments; the body usually composed of three distinct layers. *Ex. Paramecium, Vorticella, Stentor.*

SUB-KINGDOM II.—CŒLEENTERATA.

CHAPTER II.

- I. CHARACTERS OF THE SUB-KINGDOM. 2. DIVISIONS.
3. INDIVIDUALITY.

THE second great division of the animal kingdom is that of the *Cœlenterata* or "hollow-entrailed" animals (Gr. *kóilos*, hollow; *enteron*, intestine). In this sub-kingdom are included the Sea-anemones, Corals, Sea-jellies, Sea-firs, Sea-pens, and other allied animals, and the whole division may be looked upon as forming the most typical section of the animals formerly called by Cuvier *Radiata*. In addition to the above, however, the distinguished French naturalist included in his *Radiata* or "Rayed Animals" all the *Protozoa*, together with the lowest members of the *Mollusca*, and the Sea-urchins, Star-fishes, Wheel-animals, and others, which are now placed in a separate sub-kingdom under the name of *Annuloida*. For this reason the term *Radiata* has now been completely abandoned. Most of the *Cœlenterata* come under the popular term of "zoophytes," or plant-animals, from the external resemblance which many of them show to plants.

The sub-kingdom *Cœlenterata* is defined as including those animals in which *the alimentary canal opens directly into the general cavity of the body*; there is no organ of the circulation, and, as a rule, there are no traces of a nervous system; the body is made up of two fundamental membranes, an outer, called the "ectoderm" (Gr. *ektos*, outside; *derma*, skin), and an inner, called the "endoderm" (Gr. *endon*, within; *derma*, skin). Usually, if not invariably, some part or other of the body is furnished with peculiar cells, which are called "thread-cells" or "nettle-cells," and which act as weapons of offence and defence. Generally speaking, the organs round the mouth are arranged in a star-like or radiate manner, and often this arrangement extends to the internal organs as well. In all cases distinct reproductive organs are present.

The above characters distinguish the *Cœlenterata* as a whole from all other animals, but the most important peculiarity is the structure of the digestive system. In the *Protozoa*, as we have seen, a mouth is only occasionally present, and in no case do the walls of the body enclose a definite internal space or chamber, to which the name of "body-cavity" could properly be applied. In most of the higher animals, again, not only is there a mouth, but there is a distinct body-chamber; and a distinct digestive canal is usually present, which passes through the body-cavity, but does not open into it. In the *Cœlenterata* (fig. 10) the condition of parts is intermediate between these two arrangements.

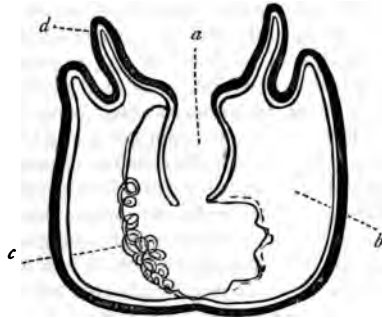


Fig. 10.—Diagrammatic vertical section of a Sea-anemone (*Actinia*). *a* Stomach; *b* Mesentery; *c* Convoluted cord or "craspedum;" *d* Tentacle.

There is always a distinct and permanent mouth, and there is always a distinct internal cavity, which is bounded by the walls of the body, and which is, therefore, called the "body-cavity." The mouth, however, does not open into an alimentary canal passing through the body-cavity without communicating with it, but either opens straight into the body-cavity (fig. 11, *a*), or into a short stomach, which in turn communicates directly with the body-cavity (fig. 10). In other words, in all the *Cœlenterate* animals, either the general body-cavity *is* the digestive cavity, or if there be a distinct digestive tube, this opens directly into the body-cavity.

Upon this structure of the digestive system is founded a division of the sub-kingdom of the *Cœlenterata* into two great classes, termed respectively the *Hydrozoa* and the *Actinozoa*. In the *Hydrozoa* there is no digestive cavity distinct from the general body-cavity, the mouth opening directly into the cavity of the body. In the *Actinozoa*, on the other hand, there is a dis-

tinct digestive sac or stomach, but this opens below directly into the body-cavity, so that the two freely communicate with one another.

Before going on to describe these classes in detail, it may be as well to shortly describe what is understood zoologically by the term "individual," as it will otherwise be impossible to arrive at any clear conception of the true nature of many of the Coelenterate animals. For this purpose it is necessary to glance briefly at the general features of reproduction as displayed in different sections of the animal kingdom. Reproduction is the process by which new individuals are produced, and the perpetuation of the species secured. In the higher animals this can only be effected by the production of an egg or ovum, which requires to be fertilised by a sperm-cell. In no other way is it possible for a fresh being to be produced amongst Vertebrate animals; and amongst these, therefore, there is not the smallest difficulty in understanding what is meant by an "individual." Each fertilised ovum gives rise to but one being, and this cannot produce another being except by producing another ovum. In this case, therefore, each separate animal is a single "individual." This is by no means the case, however, with the lower animals, many of which can give rise to fresh beings without the previous production of ova and sperm-cells. The methods by which this may be effected are various, but the only two which require to be noticed here are those in which fresh beings are produced by "gemination" or by "fission."

Gemination (Lat. *gemma*, a bud), or budding, consists in the production of a bud or buds from the outside, or sometimes from the inside, of an animal, which buds become developed into more or less completely independent beings. Generally the buds become developed into beings like the one from which they were produced, but sometimes they become very different in appearance and structure.

Fission or cleavage (Lat. *findo*, I cleave) differs from gemination only in this, that the parent organism gives rise to new beings, not by throwing out buds, but by dividing or splitting itself into two or more portions, each of which becomes more or less independent.

In either case, the new beings which are produced are technically called *zooids* (Gr. *zōon*, animal; *eidos*, form); and they do not constitute what a naturalist would look upon as "individuals." In either case, too—whether the process be one of gemination or of fission—one of two things may happen. *Firstly*, all the new beings or zooids may remain permanently

attached to one another and to the original zoöid, so that each leads an only partially independent life. In this case we get ultimately a compound being or colony, such as we have already seen in the Sponges, and shall see hereafter in the Sea-firs and Corals. *Secondly*, the new beings or zoöids may become detached from the parent organism, and may be liberated to lead a completely independent life, as in the common Fresh-water Polype. In this case we get no colony, but we have an assemblage of beings which may be all like one another, or of which some are wholly unlike the others in appearance. It should be added that in most cases the zoöids can go on producing other zoöids, by a repetition of the same process as that to which they owed their own existence. Finally, it should be added that there are cases in which some of the zoöids remain permanently attached to one another; whilst others, of a different appearance, and destined for different functions, are set free to lead an independent existence. An example of this is afforded by many of the fixed and plant-like *Hydrozoa*.

If we apply these facts to the question of what constitutes an "individual," we must come to the conclusion that the term cannot be retained in its popular sense. Scientifically, the term "individual" must be restricted to "*the total result of the development of a single ovum.*" In the higher animals, as before said, there is no difficulty about this, for each animal is the total result of the development of a single egg, and is therefore an "individual." In the lower animals, however, where fresh beings may be produced by budding or cleavage, the term "individual" can only be properly applied to the whole and entire assemblage of beings produced in this way, however widely they may differ in appearance, structure, or mode of life. An "individual," therefore, in the zoological sense of the term, may be, *firstly*, a single independent animal; *secondly*, a compound organism or colony, composed of more or less nearly similar beings, produced by budding or cleavage from a single primitive organism; *thirdly*, an assemblage of zoöids, all produced from one primitive being, but not necessarily remaining in contact with one another, nor exhibiting any common features of likeness; and *fourthly*, *two* assemblages of zoöids, the whole produced from one primitive being, the first assemblage consisting of attached zoöids, forming a fixed colony, and incapable of producing eggs; whilst the second assemblage consists of detached beings, wholly unlike the members of the colony in appearance, leading an active and independent life, and capable of producing eggs.

CHAPTER III.

CLASS I. HYDROZOA.

HYDROID ZOOPHYTES.

THE first class of the *Cælenterata* is that of the *Hydrozoa*, characterised by the fact that *the walls of the digestive sac are not separated from those of the body-cavity, the two coinciding with one another* (fig. 11, *a*). The *reproductive organs are external*, in the form of external processes of the body-wall (fig. 11, *b*).

The *Hydrozoa* are all aquatic in their habits, and, with the exception of two genera, they are all inhabitants of sea-water. The class includes both simple and compound organisms, of which the most familiar are the Sea-firs and their allies (*Hydroid Zoophytes*), the Fresh-water Polype or *Hydra*, the Portuguese Man-of-war (*Physalia*), the Sea-jellies (*Medusæ*), and the great Sea-blubbers (*Aurelia*, &c.) These animals may be taken as the representatives of the four great groups or sub-classes into which the *Hydrozoa* are divided,—viz., the *Hydroida*, *Siphonophora*, *Discophora*, and *Lucernarida*.

SUB-CLASS I. HYDROIDA.—The members of this sub-class are generally spoken of as "Hydroid Zoophytes," from their resemblance to the Fresh-water Polype (*Hydra*), which is also a member of this division. In the great majority of the Hydroid Zoophytes, we have to deal with compound animals, consisting of a greater or less number of similar zooids, all united by a common trunk, the whole fixed permanently to some solid object. In some few cases, however, the organism consists of no more than a single "polypite,"* which is sometimes attached, but can sometimes detach itself at will. As examples of the Hydroid Zoophytes may be taken the common Fresh-water

* The term "polypite" is employed to designate the separate zooids of which the colonies of the compound *Hydrozoa* are composed. Where the animal consists of no more than one being, as in the common *Hydra*, the term polypite is applied to entire animal.

Polypes (*Hydra*), the Pipe-coralline (*Tubularia*), and the Sea-firs (*Sertularia*).

The common *Hydræ* or Fresh-water Polypes may be found in tolerable plenty in most of our ponds, and are quite visible to the unassisted eye. The body of the *Hydra* (fig. 11, *a*, *b*) is in the form of a cylindrical tube, composed of the two fundamental membranes, the ectoderm and endoderm, of which the former contains numerous thread-cells. At the base of the cylindrical body is a kind of sucker, by which the animal can attach itself to some foreign object, such as a piece of water-weed. It is not, however, permanently fixed, but can detach itself and change its place at will. At the opposite end of the

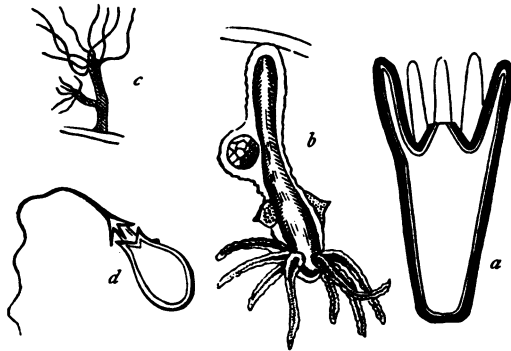


Fig. 11.—Diagrammatic section of *Hydra*. The dark line is the ectoderm, the fine line and clear space adjacent indicate the endoderm. *b* *Hydra viridis*, showing the externally-placed reproductive organs; *c* *Hydra vulgaris*, with an undetached bud; *d* Thread-cell of the *Hydra*, greatly magnified.

body is placed the mouth, surrounded by from five to fifteen small filaments, which are arranged in a circle and are known as the "tentacles." The tentacles consist of tubular prolongations of the ectoderm and endoderm, and they are richly furnished with thread-cells. In some species they are longer than in others, but all possess the power of drawing the tentacles in at pleasure, and again pushing them out, to a length which sometimes many times exceeds the entire length of the body. The tentacles are the organs by which the *Hydra* catches its food, in which operation they not only act mechanically, seizing the prey and conducting it to the mouth, but they appear also to exercise a benumbing influence upon the animals grasped by them. The mouth opens directly into a long cylindrical cavity,

which is excavated along the whole length of the body, and which is truly the body-cavity. It is here, however, that the digestion of the food is carried on, and it is therefore to be regarded as being at the same time the stomach. As before said, the outer layer or ectoderm both of the body and tentacles is richly furnished with the minute offensive weapons known as "thread-cells," or "nettle-cells." Each of these (fig. 11, *d*) consists of a little bladder, in the interior of which is coiled up a long filament or thread. When the sac is touched, the thread-like dart within it is thrust out with the rapidity of lightning, its length often exceeding that of the cell many times. In the case of the *Hydra*, these threads have not the power of piercing the human skin, and they are, therefore, harmless so far as man is concerned. In the case of the great Sea-blubbers, however, and in some Sea-anemones, the thread-cells are capable of stinging very severely, as their darts can penetrate the skin.

Reproduction is effected in the *Hydra* by two different processes. In summer, when food is plentiful and the animal is vigorous, the *Hydra* produces young "polypites" by a process of budding. The animal throws out from some part of its surface a little knob or bud, composed of both the layers which wall in the cavity of the body. This is ultimately developed into a fresh *Hydra*, which is detached to lead an independent existence. In the autumn, when the temperature is low and food scarce, the *Hydra* produces eggs and sperm-cells in outward processes of the body-wall (fig. 11, *b*), and by the contact of these young are produced.

The last point about the *Hydra* which needs notice is their extraordinary power of resisting mutilation. Thus the body of a *Hydra* may be divided into as many portions as we please with a knife, and the result is that, instead of the animal being killed, each and all of the fragments become developed into perfect *Hydra*. Still further, the animal may even be turned inside out without thereby seeming to suffer any injury.

The Pipe-coraline (*Tubularia*) is an example of another group of the Hydroid Zoophytes, almost all the members of which are marine. *Tubularia* (fig. 12) is gregarious in its habits, and consists of numerous clustered horny tubes, which resemble straws in appearance, and are fixed by their bases to some solid object, such as a shell or stone. Each tube is filled with a soft semi-fluid reddish substance, and from its open extremity can be protruded a single polypite. The polypites are bright red in colour, and cannot fully be withdrawn within their tubes. The mouth is placed at the free end of the poly-

pite, and is surrounded by two rows of tentacles, one consisting of numerous short tentacles placed directly round the mouth, whilst the other is composed of from thirty to forty filaments of much greater length, arising from the polypite about its middle or near the base. Near the insertion of these long tentacles, at proper seasons, are produced buds, in which the elements of reproduction (the ova and sperm-cells) are produced; but the buds themselves are not detached from the polypite. These "generative buds" in *Tubularia*, and in all the other *Hydrozoa* in which they occur, are technically called "gonophores" (Gr. *gonos*, offspring; *phero*, I carry).

As the last example of the Hydroid Zoophytes, we may take the Sea-firs, technically called *Sertularians* (fig. 13). Every visitor at the sea-side is acquainted with the Sea-firs and their allies; but they are usually, in fact almost invariably, set down as sea-weeds. What we pick up, however, on the shore, is not the true animal, but is simply its outer covering or skeleton, which is composed of a brown horny substance. To form an accurate idea of a Sea-fir or Sertularian, we have two things to place before our imagination. We must, firstly, imagine that we have a number of little animals (fig. 13, *b*), in all essential points of their structure exactly similar to the *Hydra*, but all permanently united to one another by a common branched stem or trunk, which is termed the "cœnosarc" (Gr. *koinos*, common; *sarx*, flesh). This assemblage of little Hydra-like beings—polypites or zooids—forms a permanent colony, all the members of which are attached for life to one another. The entire colony is produced by budding from a single primitive zooid, and each zooid is exactly like the *Hydra* in essential structure. Each, namely, consists of a little cup-shaped or cylindrical body, enclosing a single chamber, which is both body-cavity and stomach, and having at one end a mouth surrounded by a



Fig. 12.—Fragment of *Tubularia indivisa*, natural size.

circlet of tentacles (fig. 13, *b*). At its lower end the body-cavity opens into a tubular cavity, which is everywhere excavated in the substance of the common connecting trunk or "cœnosarc,"

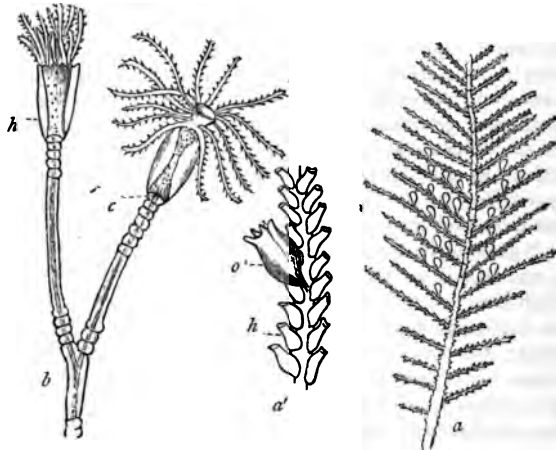


Fig. 13.—*a* Fragment of *Sertularia pinnata*, natural size; *a'* Branch of the same magnified, showing the little cells ("hydrothecæ") in which the polypites are contained, and also a reproductive capsule; *b* Fragment of *Campanularia neglecta* (after Hincks), showing the polypites in their cups. Magnified.

and which is filled with a nutritive fluid, by means of which the vitality of the whole colony is maintained. The *animal*, then, of a Sertularian, is composed of this colony of hydra-like polypites, united by a branched trunk. To complete, however, our conception of a Sertularian, we have, secondly, to imagine that the entire colony is invested by a strong brown horny case or sheath. This structure—the so-called "polypary"—forms a closely adherent sheath or covering for the whole "cœnosarc" or common trunk, as it does in *Tubularia*; but it differs from the latter in also expanding to form little cups for each separate zoöid (fig. 13, *a'*, *b*). These little cups are open at one end, and each polypite has the power of putting out its head from the open aperture of its little cup-shaped case, or again of retiring entirely within it for protection. They are technically known as "hydrothecæ" (Gr. *hydra*; and *theke*, a case).

These two conceptions give us accurately the structure of any common *Sertularian*; but we now know that this is only half their history, and we have now very briefly to consider some very remarkable facts concerning the mode in which these

plant-like colonies are reproduced. The entire colony of a *Sertularian*, such as has been described, is produced by budding from a single primitive zoöid, and is permanently fixed and rooted. None of the ordinary zoöids have any power of producing eggs, and it is quite obvious that the species could never spread from one place to another, and so maintain its existence, unless there were some special means provided to insure this. At certain times of the year, however, we find, if we examine any common Sertularian, that, besides the ordinary zoöids of the colony, there are larger and differently-shaped structures, usually enclosed in urn-shaped receptacles, attached to the branches (fig. 13, *a*). These are receptacles in which are peculiarly-modified zoöids, the function of which is to produce the eggs which the ordinary zoöids are unable to develop. When the eggs are ripe, the receptacles, or "ovarian capsules" as they are often called, rupture, and set the eggs free into the surrounding water. Each egg now gives exit to a little embryo, which is covered with vibrating cilia, by means of which it swims about actively. After a time the active embryo fixes upon some suitable locality, attaches itself by one extremity to some solid object, develops a mouth and tentacles at the opposite end, and becomes in every respect an animal like the common *Hydra*. It now begins, however, to throw out buds, and it encases itself in a horny sheath, till ultimately there is produced another plant-like colony, just like the one on which the ovarian vesicles were produced.

This is the process by which the perpetuation and diffusion of the species is secured amongst many *Sertularians*; but in others much more extraordinary facts are observed. In the process just described, the modified egg-producing zoöid or "gonophore" remains permanently attached to the parent colony, and simply lets loose a number of ciliated embryos, which swim about till they find a suitable resting-place. In other cases, however, the egg-producing zoöid is bodily detached from the parent colony. In these cases the liberated gonophore becomes highly developed, and its structure is so modified that it is enabled to live a completely independent existence for a shorter or longer period. It now constitutes one of the creatures which are popularly known as Jelly-fish, and which are scientifically called "Medusoids" or "Medusiform gonophores." Each Medusoid (fig. 14) consists of a delicate, transparent, glassy bell or disc, from the under surface of which, like the clapper of the bell, is suspended a single modified polypite (*a*). The whole organism swims gaily through

the water, propelled by the contractions of the bell or disc; and no one would now suspect that it had any relationship to the rooted and plant-like Zoophyte from which it was originally budded off.

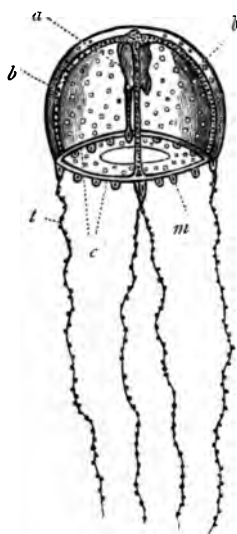


Fig. 14. — Free medusiform gonophore of *Clytia johnstoni* (after Hincks). *a* Central polypite; *b* Radiating canals of the disc; *c* Circular canal; *m* Marginal bodies or eye-specks; *t* Tentacles.

The central polypite is furnished with a mouth, which opens into a digestive cavity or stomach. From the stomach arise four radiating canals (*b b*), which proceed to the margin of the bell, where they are united by a circular vessel (*c*) which runs round the mouth of the bell. From the circumference of the bell hang also a number of delicate filaments or tentacles (*t*), and the margin is adorned with a number of brightly-coloured spots (*m*), which are probably rudimentary organs of vision and hearing. Lastly, the mouth of the bell is partially closed by a delicate transparent membrane, the so-called "veil." Thus constituted, these beautiful little beings lead an independent and locomotive existence for a longer or shorter period. Ultimately, ova and sperm-cells are produced in special organs, which are developed in the course of the radiating canals of the disc, or in the

walls of the polypite. The eggs give rise to ciliated embryos, which, according to all our ordinary notions, ought to become Jelly-fish; the young in ordinary cases developing itself into the organism by which the egg was produced. This is not the case here, however, but the embryos fix themselves, and become developed by budding into the fixed plant-like colony, from which the Medusoids were originally derived.

CHAPTER IV.

SIPHONOPHORA, DISCOPHORA, LUCERNARIDA.

SUB-CLASS II. SIPHONOPHORA.—The remaining members of the *Hydrozoa* require but brief notice, as the Hydroid Zoophytes are the most commonly met with and most familiar forms of the group. In the sub-class *Siphonophora* we have a number of animals which are often spoken of as the "Oceanic Hydrozoa," as they are not fixed to one place, but are found swimming at the surface of the open ocean far from land. They are all singularly delicate and beautiful organisms, and they are divided into two groups, as examples of which may be taken *Diphyes*, and the Portuguese Man-of-war (*Physalia*).

Diphyes (fig. 15) consists of a long thread-like trunk or "cœnosarc" (*c*), which bears at intervals minute polypites, each of which is protected by a delicate, glassy, overlapping plate. Each polypite is likewise furnished with a single tentacle, which gives off lateral branches on one side. At one extremity of the cœnosarc are two large mitre-shaped "swimming-bells," by the contractions of which the entire organism is driven through the water. The cœnosarc with its polypites can be withdrawn, when necessary, into a kind of chamber between the two swimming-bells; but when unretracted the organism often attains a length of several inches. Its name is derived from the fact that the two swimming-bells can be separated from the cœnosarc by the

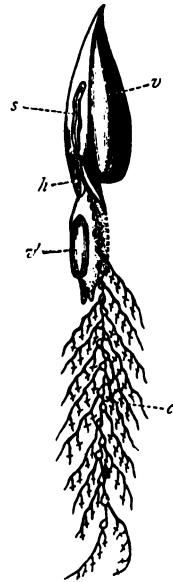


Fig. 15.—*Diphyes appendiculata* (after Kölliker); *v, v'* Swimming-bells; *c* Cœnosarc with polypites, each with its tentacle.

least touch, and it was hence originally supposed to consist of two distinct animals loosely attached to one another.

In the Portuguese Man-of-war (*Physalia*, fig. 16, *a*) the animal floats near or at the surface of the sea by means of a long spindle-shaped "float," which is filled with air. The float may be several inches in length, and from its under surface



Fig. 16.—*a* Portuguese Man-of-war (after Huxley);
b *Verella* (after Gosse).

surface hang a number of polypites, with highly contractile tentacles, and reproductive organs. The tentacles are often many feet in length, and have the power of stinging very severely, from the presence in them of numerous thread-cells. In *Verella* (fig. 16, *b*) we have an animal nearly allied to *Physalia*, but having a flattened, disc-like float, upon the upper surface of which is carried a vertical triangular crest which officiates as a sail. From the under surface of this hang numerous tentacles and small reproductive processes, with a single large

central polypite. It is of a beautiful bluish colour and semi-transparent, and, like the Portuguese Man-of-war, it is occasionally driven upon our coasts, though really a native of warmer seas than ours.

SUB-CLASS III. DISCOPHORA.—The organisms included under this head are commonly called Jelly-fish, Sea-jellies, or, scientifically, *Medusæ*. In this group, however, are only comprised a number of small Jelly-fish, little known to the general public in consequence of their diminutive size; whilst the great Sea-blubbers or Sea-nettles really belong to the sub-class

Lucernarida. It is now certain, also, that many of the organisms which were formerly placed under this head, are really nothing more than the free-swimming reproductive buds or "medusi-form gonophores" of other *Hydrozoa*, such as the one figured in fig. 14. That this is the true nature of many of these little organisms is shown by the fact that the eggs which they produce develop themselves, not into Jelly-fishes, but into various other forms of *Hydrozoa*, which may be fixed or may be oceanic. No Jelly-fishes, therefore, can be retained in the group of the *Discophora* or *Medusida*, except those few whose eggs are shown to develop into the likeness of the Jelly-fish by which they were produced. With these may be provisionally included all those Jelly-fishes whose development is as yet unknown.

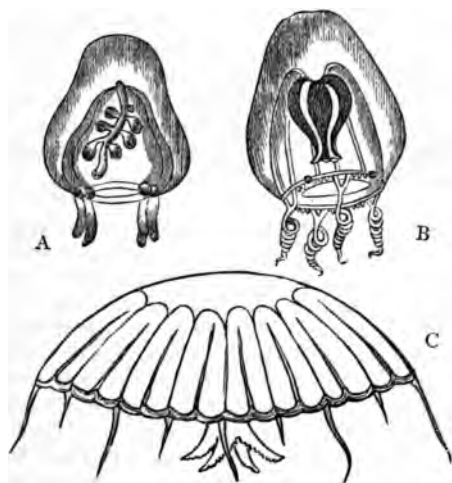


Fig. 17.—Naked-eyed Medusæ. A, *Sarsia*; B, *Modoceria*; C, *Polyxenia*.
(After Gosse.)

It will hardly be necessary to enter into any details as to the structure of the *Medusæ*, as it is in all essential respects exactly identical with what has been already described in speaking of the free-swimming reproductive buds of the Hydroid Zoophytes. A *Medusa* (fig. 17) consists of a thick, transparent, gelatinous disc or swimming-bell, by the contractions of which the organism is driven through the water. From the summit of the bell-shaped disc hangs a single polypite, with a mouth and

digestive sac. From the upper end of the stomach proceed four canals which radiate to the circumference, where they open into a circular vessel. The margin of the bell is narrowed by a kind of transparent "veil," and is furnished with more or less numerous tentacles. The margin of the disc is also provided with conspicuous coloured spots, which are known as the marginal bodies, and appear to be concerned with vision. From the unprotected position of these marginal bodies this group of Jelly-fish is often spoken of as the "naked-eyed" *Medusa*, to distinguish them from the great Sea-blubbers, which have the marginal bodies protected by a sort of hood, and which are therefore sometimes called "hidden-eyed" *Medusa*. The reproductive organs are mostly developed in the course of the radiating canals of the disc.

The naked-eyed *Medusa* are exceedingly elegant and attractive in their appearance, when examined in a living condition, resembling little bells of glass, perfectly transparent, and often adorned with very brilliant colours. They are mostly phosphorescent, or capable of giving out light at night; but it does not seem that they exercise this power unless disturbed or irritated in some way.

SUB-CLASS IV. LUCERNARIDA.—Very various organisms are included under this head, but it is only possible to notice those which were formerly termed "hidden-eyed" *Medusa*, and which are familiarly known as Sea-nettles or Sea-blubbers. Every sea-side visitor is familiar with the great circular discs of jelly which are left upon the sands by the retreating tide during the summer months; many must have noticed them slowly flapping their way through the water by means of their large transparent discs; and some few may have found by painful experience that they can sting severely if incautiously handled. They all present a decided external resemblance to the little "naked-eyed" *Medusa*, but they differ considerably amongst themselves both in their actual nature and in anatomical structure. Some of them produce eggs which are developed into organisms resembling themselves; but most of them are now known to be the free-swimming reproductive buds of minute-rooted *Hydrozoa*. It will be sufficient here to describe briefly the life-history of one of the British examples of these latter.

If we commence with the egg of one of these singular organisms, we find that it gives origin to a minute ciliated body (fig. 18, a), which swims about actively by means of its cilia.

This little body ultimately fixes itself, becomes trumpet-shaped, and develops a mouth and tentacles at its expanded extremity, when it is known as the "Hydra-tuba," from its resemblance in shape to the Fresh-water Polype or *Hydra* (fig. 18, *b*). The

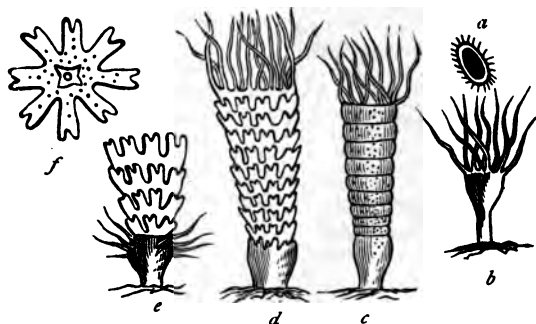


Fig. 18.—Development of the Lucernarida. *a* Ciliated embryo; *b* Hydra-tuba; *c* Hydra-tuba beginning to divide by transverse cleavage; *d* The cleavage further advanced; *e* A form in which the cleavage is still further advanced, and a fresh circle of tentacles has been produced near the base; *f* Free-swimming generative body, produced by cleavage from the Hydra-tuba.

Hydra-tuba is only about half an inch in height, and it can form large colonies by budding, but it cannot produce eggs. Under certain circumstances, however, the Hydra-tuba enlarges, and, after a series of preliminary changes (fig. 18, *c*, *d*, *e*), divides by transverse cleavage into a number of segments, each of which becomes detached and swims away. The liberated segments have the structure of "hidden-eyed" *Medusæ*, and increase rapidly in size, becoming, not only comparatively, but often actually, gigantic. These enormous reproductive bodies lead an active and independent life till they are able to develop ova and sperm-cells in their interior, when they die. The fertilised egg, however, develops itself, not into the monstrous organism by which it was produced, but into the little fixed Hydra-tuba, from which the generative segment was originally given off.

The Sea-blubbers, as already remarked, present a decided superficial resemblance to the "naked-eyed" or true *Medusæ*; but they may be distinguished by the following points. The body of one of the Sea-blubbers (fig. 19) consists of a great bell-shaped gelatinous disc or swimming-bell, which is known as the "umbrella." From the roof of this is suspended a

single polypite (in the forms under consideration), the lips of which are extended into lobed processes, often reaching far below the margin



Fig. 19.—Generative zooid of one of the *Lucernarida* (*Chrysaora hysoscella*), after Gosse.

of the disc. The digestive cavity of the polypite gives out a series of radiating canals, but these differ from those of the naked-eyed *Medusa* in being never less than eight in number, and in breaking up into a network before they ultimately open into the circular canal which runs round the margin of the umbrella. Tentacles and "marginal bodies" are present; but the latter are protected by a sort of hood, and are not exposed to view, as they are in the true *Medusa*. The mouth of the bell is not narrowed by a membranous shelf or "veil," as in the naked-

eyed forms; and lastly, the reproductive organs are usually of some bright colour, and "form a conspicuous cross shining through the thickness of the disc" (Greene).

CHAPTER V.

CLASS II. ACTINOZOA.

THE second great class of the *Cœlenterata* is that of the *Actinozoa*, comprising the Sea-anemones and their allies, the Corals, the Sea-pens, the Sea-shrubs, and various other organisms. They are distinguished from the *Hydrozoa* by the fact that the mouth opens into a distinct digestive sac or stomach (fig. 10), which in turn communicates by a wide opening with the cavity of the body. The reproductive organs are *internal*. The body-walls are separated from the walls of the stomach by a space (fig. 20, A), which is divided into a number of chambers by a series of partitions which are known as the "mesenteries." The result of this arrangement is, that whilst the body of a *Hydrozoön*, if cut in two, exhibits only a single tube, formed by the walls of the body-cavity, the body of an *Actinozoön* exhibits *two* concentric tubes, one formed by the walls of the stomach and the other by those of the body (fig. 20).

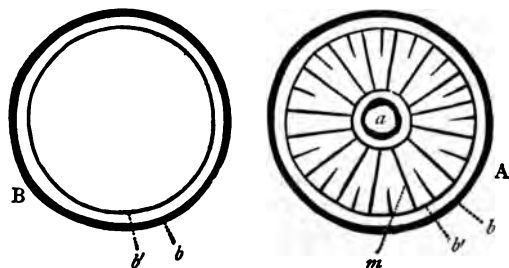


Fig. 20.—A, Transverse section of an *Actinozoön*. *a* Digestive sac; *b* Wall of the body; *m* Mesenteries, connecting the stomach with the body-walls, and dividing the space between the two into a number of vertical chambers. B, Transverse section of a *Hydrozoön*, showing the single tube formed by the walls of the body.

In the other essential details of their structure, the *Actinozoa*

do not differ from the *Hydrozoa*. The body is composed of two fundamental layers, an ectoderm and endoderm, and thread-cells are usually present in abundance. There are no traces of a nervous system except in one order (*Ctenophora*); and in none is there any circulatory system. Distinct reproductive organs are always present, and true sexual reproduction occurs in all. In many cases, however, the *Actinozoa* exhibit budding or cleavage; the result being the formation of compound organisms or colonies. In these cases—as in most of the Corals—the separate beings or zoöids produced by either of these methods are termed “polypes”—the term “polypite” being exclusively confined to the *Hydrozoa*. Where, however, the *Actinozoön* consists of but a single being, it is also termed a polype, as in most of the Sea-anemones. Most of the *Actinozoa* are permanently fixed, as the greater number of the Corals; some, like the Sea-anemones, possess a limited amount of locomotive power; and one order, the *Ctenophora*, is composed of active free-swimming organisms. Some are unprovided with any hard structures or supports, as the Sea-anemones and *Ctenophora*; but a great many produce a calcareous or horny skeleton or framework, which is known as the “coral” or “corallum.”

The *Actinozoa* are divided into the three living orders of the *Zoantharia*, *Alcyonaria*, and *Ctenophora*, each of which must be briefly noticed.

ORDER I. ZOANTHARIA.—The *Actinozoa*, comprised in this order, are distinguished by having *smooth, simple, usually numerous tentacles, which, like the mesenteries, are in multiples of five or six*. The best known and most important members of the order are the Sea-anemones and the “reef-building” Corals.

The Sea-anemones (*Actinidæ*) occur on every coast, and are familiar to every visitor at the sea-side. The body (fig. 21, *a*) is in the form of a truncated cone or short cylinder, and is of a soft leathery consistence. One end of the body forms a kind of sucker, by means of which the animal can fix itself at pleasure to any solid body; and at the opposite end is the mouth. The mouth is surrounded by a flat space without appendages, and this, in turn, is surrounded by numerous simple smooth tentacles, arranged in alternating rows. The tentacles are hollow, and can, as a general rule, be both protruded to a great length and again retracted. The mouth opens into a wide and capacious stomach, which extends about half-way between the mouth

and the base, and opens below into the body-cavity (fig. 10). The wide space between the stomach and body-walls is divided into a number of chambers by vertical plates or "mesenteries" (fig. 20, A), to the faces of which the reproductive organs are attached. Below the stomach, the free edges of the mesenteries carry certain curious twisted cords, charged with thread-cells, which are termed "craspeda," and are of quite unknown function. The Sea-anemones are mostly found between tide-marks in rock-pools, or on ledges of stone, adhering to solid objects by means of the sucker-like base. They are not, however, permanently fixed, but can remove their place at will; and some forms, such as *Arachnactis* (fig. 21, *b*), appear to be permanently free.

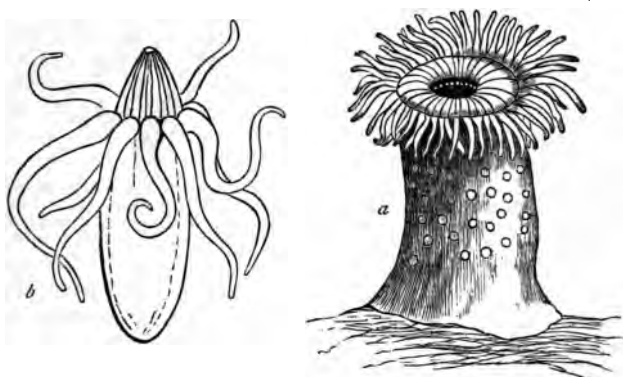


Fig. 21.—*a* *Actinia rosea*; *b* *Arachnactis albida*. (After Gosse.)

The simplest forms of Corals exactly resemble the Sea-anemones in structure, but differ in having the power of producing in their interior a hard calcareous structure or "coral." Most of the Corals, however, are less simple than this, for they form extensive colonies by means of budding or cleavage. In order, therefore, to form a clear conception of one of these compound Corals, we must imagine a great number of polypes, like the Sea-anemones in actual structure, but smaller as a rule, united together by a common flesh, whilst the whole colony has the power of secreting a calcareous framework or skeleton. If, therefore, we examine the skeleton or "coral" of one of these compound organisms, we see a number of little cups (fig. 22, *a*), each of which formerly held a little polype, the whole united

together by calcareous matter deposited by the common trunk or "cænosarc" of the polypes.

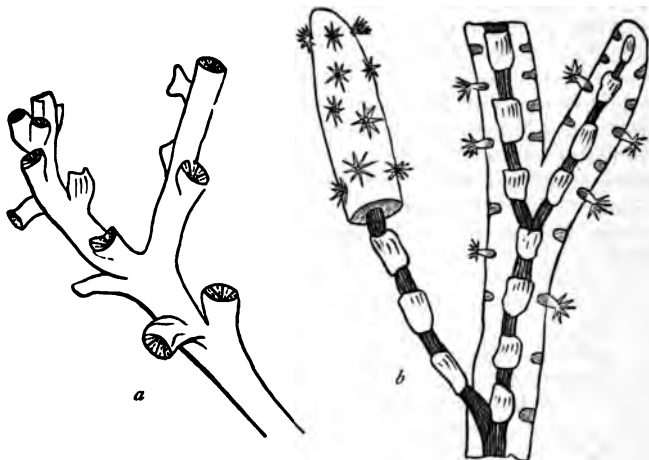


Fig. 22.—*a* Portion of a branch of *Dendrophyllia* (after Dana), showing the cups in which the polypes were contained; *b* Section of *Isis hippuris* (after Jones), showing the coral in the centre, surrounded by a bark or rind, in which the polypes are embedded.

The Corals are chiefly of interest, not so much from their anatomical structure, but on account of their forming the structures known as "coral-reefs." A coral-reef is a mass of coral produced by the combined growth of a number of colonies of coral-producing zoophytes. They occur in many places, but they are most abundant in the Indian Ocean, the Pacific Archipelago, and round the shores of Australia. Three kinds of reefs are known :—

1. *Fringing-reefs*.—These are reefs of comparatively small size, surrounding islands or skirting continents, and having no great depth of water either outside or inside.

2. *Atolls*.—These are reefs which form more or less complete rings, circular or oval in shape, and enclosing a central lagoon without any land.

3. *Barrier-reefs*.—These surround islands or skirt continents, and differ from fringing-reefs chiefly in the great depth of the water outside, and the great comparative width of the channel inside between the reef and the land. Barrier-reefs are the most interesting of all the coral-reefs, and a few words may be

said as to one of the best known, the great Barrier-reef of Australia. This colossal reef extends as a gigantic wall along the N.E. coast of Australia, from Breaksea Spit to Bristow Island, a length of over 1100 miles. During the whole of this course it keeps at a distance of some miles from the land, from which it is separated by a channel of smooth water, which has an average depth of from 20 to 30 fathoms. The average breadth of the reef itself is about 30 miles, and it has a superficial area of about 33,000 square miles. Its continuity is rarely broken by narrow channels which let in the water from the sea outside, the depth of which, close to the reef, is from 500 to 1800 feet. The seaward face of the reef is constantly beaten by the most tremendous surf imaginable, produced by the sudden stoppage of the long rollers which come in from the open ocean; but the inner channel for the same reason is perfectly calm.

The mode of origin of coral-reefs, and the habits of the coral-zoophytes, are subjects of great interest; but space will not permit of their discussion here. It is to the patient industry of Mr Darwin that we owe the above division and the theory as to the origin of coral-reefs, which is now generally accepted.

ORDER II. ALCYONARIA.—The second great order of *Actinosea* is distinguished by the fact that the polypes are furnished with *fringed* tentacles, and that these, as well as the mesenteries, are always some multiple of *four* in number (usually eight). Several of the Alcyonarian Polypes are more or less familiarly known, such as the Dead-men's-fingers (*Alcyonium*), the Organ-pipe Coral (*Tubipora*), and the Sea-rod (*Virgularia*); but it will be enough to notice the Sea-pen (*Pennatula*) and the Red Coral (*Corallium rubrum*).

The Sea-pen or Cocks-comb (fig. 23) is not uncommonly found in our seas, on muddy bottoms, in moderately deep water. It varies from 2 to 4 inches in length, and appears to live with its lower extremity sunk in the mud of the sea-bottom. It presents a kind of resemblance to a feather, its lower portion being naked, whilst the upper part is fringed with lateral processes on both sides. The lower smooth portion is fleshy, and is strengthened by a long, slender internal skeleton or coral. The lateral fringes of the upper portion carry numerous small polypes. The general colour of *Pennatula* is deep reddish purple, passing into orange yellow at the base. Our British species phosphoresces brilliantly when irritated.

The best known of the *Alcyonaria* is the Red Coral of commerce (*Corallium rubrum*), which is largely imported for orna-

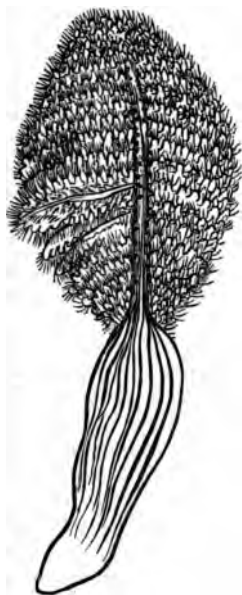


Fig. 23.—*Pennatulula phosphorea*
(after Johnston).

mental purposes from the Mediterranean. In this species there is an internal skeleton, in the form of a bright-red, finely-grooved coral, of great density, and composed of carbonate of lime. The coral is usually more or less repeatedly branched, and is invested by a bright-red bark or rind, which is studded with numerous little apertures. From these openings the polypes can be thrust out at will, each being of a milk-white colour, and having eight fringed tentacles. The entire fleshy bark is excavated into a number of communicating canals, with which the digestive cavities of the polypes are connected, the whole system being filled with a nutritive fluid, known as the "milk." The general structure of *Corallium* will be at once understood by a reference to the figure of *Isis* (fig. 22, *b*), which is nearly related to Red Coral, but in which the coral is composed of alternate segments of horny matter and lime.

ORDER III. CTENOPHORA.—The last order of living *Actinozoa* is that of the *Ctenophora*, of which *Pleurobrachia* (fig. 24) may be taken as the type. This beautiful little organism is found, like all the other members of the order, swimming in the open ocean. The organs by which locomotion is effected are numerous transverse rows or comb-like plates of cilia, arranged in longitudinal bands; hence the name *Ctenophora* (Gr. *kteis*, a comb; *phero*, I bear). The body of *Pleurobrachia* is melon-shaped, gelatinous, transparent, and colourless, and exhibits two poles, at one of which is placed the mouth. Besides the ciliated bands, there are two very long and flexible tentacles, which can be instantaneously thrust out, and as instantaneously withdrawn, at the will of the animal. The mouth opens below into a spindle-shaped stomach, which is in connection with a

complicated canal-system, which is ciliated internally, and is filled with a nutrient fluid. Near the opposite pole of the body

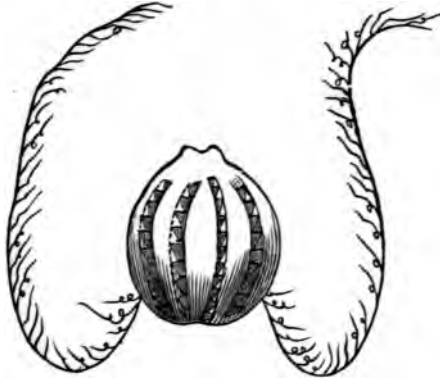


Fig. 24.—*Pleurobrachia pileus*.

to the mouth is a little vesicle or sac, believed to be a rudimentary organ of hearing, and placed upon this is a little mass which is generally believed to be of a nervous nature. If so, this is the first indication we have hitherto encountered of a genuine nervous system.

More generally known than the preceding is the "Venus's Girdle" (*Cestum*), which agrees in essential points with *Pleurobrachia*, but is greatly elongated in a direction at right angles to the digestive canal, so that a ribbon-shaped body is produced 4 or 5 feet in length, and 2 or 3 inches high. *Cestum* is not uncommon in the Mediterranean, and has the power of phosphorescence, appearing at night as a moving and twisting band of flame.

TABLE OF THE DIVISIONS OF THE CÆLENTERATA.

CLASS I. HYDROZOA.—The walls of the digestive sac not separated from those of the body-cavity. The reproductive organs external.

Sub-class 1. Hydroida.—*Ex.* Hydra, Pipe-coralline (Tubularia), Sea-firs (Sertularia).

Sub-class 2. Siphonophora.—*Ex.* Diphyes, Portuguese Man-of-war (Physalia).

Sub-class 3. Discophora.—*Ex.* Thaumantias.

Sub-class 4. Lucernarida.—*Ex.* Chrysaora.

CLASS II. ACTINOZOA. — Digestive sac distinct from the general cavity of the body, but opening into it. Reproductive organs internal.

Order 1. Zoantharia.—*Ex.* Sea-anemones (Actinia), Reef-building Corals.

Order 2. Alcyonaria.—*Ex.* Sea-pen (Pennatula), Sea-shrub (Gorgonia), Red Coral (Corallium).

Order 3. Ctenophora.—*Ex.* Pleurobrachia, Venus's Girdle (Cestum).

SUB-KINGDOM III.—ANNULOIDA.

CHAPTER VI.

ECHINODERMATA.

THE third primary division of the animal kingdom is known by the name of *Annuloida* (Lat. *annulus*, a ring ; Gr. *eidos*, form), and includes two groups of organisms which are very unlike one another in appearance, and are termed respectively the *Echinodermata* and *Scolecida*. In the former are included the Sea-urchins, Star-fishes, and their allies, formerly classed in the old sub-kingdom *Radiata*; in the latter are a number of internal parasites, with some minute aquatic animals. The sub-kingdom *Annuloida* is characterised by possessing a *distinct alimentary canal* (absent in some internal parasites), which usually communicates with the outer world by two apertures (a mouth and a vent), and in any case is completely shut off from the general cavity of the body. *In all there is a distinct nervous system; and in all there is a peculiar system of canals usually communicating with the exterior, and known as the "water-vascular" system.*

CLASS I. ECHINODERMATA.

This class contains the Sea-urchins, Star-fishes, Sand-stars, Feather-stars, Sea-cucumbers, &c., and derives its name from the prickly nature of the skin in most of its members (Gr. *echinos*, a hedgehog; *derma*, skin). In all, the skin has the power of secreting lime, but the extent of this power varies much. When adult, they all show a more or less distinctly ray-like or "radiate" arrangement of their parts, which is most conspicuous in the star-shaped Star-fishes and Sand-stars, but can be detected in all the members of the class. When young, however, they almost always exhibit more or less of what is called "bilateral symmetry"—that is to say, they show similar parts on the two sides of the body. In all there is a "water-vascular system"

of canals, which is termed the "ambulacral system," generally communicates with the exterior, and is mostly used in locomotion. An alimentary canal is always present, and is always completely shut off from the general cavity of the body. There are always distinct organs of reproduction, which are almost always placed in different individuals, so that the sexes are distinct. The nervous system is in the form of a ring, surrounding the gullet, and sending branches in a radiating manner to different parts of the body.

The *Echinodermata* are divided into five recent orders and two extinct, of which only the former need be considered here :—

1. *Echinoidea* (Sea-urchins).
2. *Asteroidea* (Star-fishes).
3. *Ophiuroidea* (Brittle-stars).
4. *Crinoidea* (Feather-stars).
5. *Holothuroidea* (Sea-cucumbers).

ORDER I. ECHINOIDEA.—The Sea-urchins or Sea-eggs, which form this order, vary in form from a globe to a flattened cake,

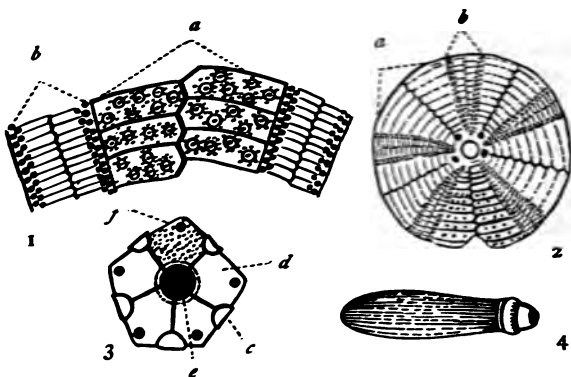


Fig. 25.—1. Portion of the test of a Sea-urchin (*Galerites*), enlarged. 2. Test of the same viewed from above; *a* Inter-ambulacral areas; *b* Ambulacral areas. 3. Genital disc of a Sea-urchin, enlarged, showing the perforated genital plates (*d*), the little ocular plates (*c*), the anus (*e*), and the madreporiform tubercle (*f*). 4. Spine of a Sea-urchin. (After Forbes.)

and are characterised by having the body encased in a "test" or shell, composed of numerous calcareous plates, which (with one exception) are immovably jointed together so as to form a kind of box (fig. 26).

The "test" or shell of a Sea-urchin (fig. 25, 1, 2) is mainly composed, in all living forms, of twenty rows of calcareous plates, arranged in ten alternating zones, each zone composed of two rows of plates. In five of these zones (fig. 25, 1 *a*, 2 *a*) the plates are of large size, and are not perforated by any holes. These are termed the "inter-ambulacral areas." In the other five zones (*b*, *b*) the plates are much smaller, and are perforated by little holes, through which can be protruded the delicate suctional tubes, which are known as the "tube-feet." These zones are called the "ambulacral areas." The main part of the test is made up of these ten zones; but besides these there are other plates developed in the leathery skin round the mouth and vent. The most important of these supernumerary plates form a kind of disc, which is placed at the summit of the shell, and generally has the opening of the vent in its centre. This disc (fig. 25, 3) is composed of ten plates, of which five are perforated for the ducts of the reproductive organs, and five, of smaller size, carry each an eye-spot. One of the genital plates (*f*) is also larger than the others, and carries a spongy mass—the so-called "madreporiform tubercle," which protects the entrance of the ambulacral system. Lastly, the whole of the test is

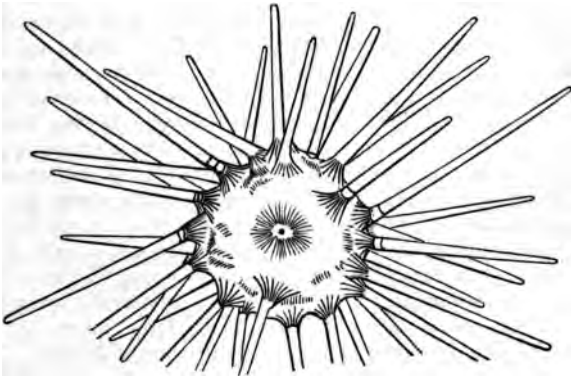


Fig. 26.—*Cidaris papillata* (after Gosse).

covered with numerous tubercles of different sizes, which carry longer or shorter spines or prickles, from the presence of which the name of "Sea-urchin" is derived. The spines (fig. 26) vary in length in different species, can be moved at the will of the animal, and doubtless act both as defensive weapons and as locomotive organs.

Locomotion is mainly effected in the Sea-urchins by a singular system of contractile tubes, which are known as the "tube-feet," and which are appendages of the water-vascular system. These tube-feet are very numerous, and they can be protruded at will from the little holes in the "ambulacral zones." Each terminates in a little sucker or disc, and by the combined action of numbers of these working together the Sea-urchin drags its ponderous body along. Water is admitted to the tube-feet by five radiating canals, which run along the five ambulacral zones, and which spring from a circular vessel round the gullet. This, in turn, receives water by means of a canal which opens at the surface by the "madreporiform tubercle."

The mouth of the Sea-urchin is armed with a curious apparatus of calcareous teeth, and conducts into a long and convoluted alimentary canal, which is attached to the interior of the shell by a delicate membrane or "mesentery," and terminates in a distinct vent. There are no very definite organs of respiration, and this function appears to be discharged partly by certain portions of the ambulacral system, and partly by the ciliated surface of the digestive canal and mesentery. Besides the ambulacral system, there is another system of tubes, the chief portions of which consist of two rings placed round opposite ends of the alimentary canal, and united by an intermediate contractile chamber. This has generally been looked upon as the representative of the circulatory or blood-vascular system of higher animals, but is now often regarded as corresponding with the so-called "pseudo-hæmal" system of the Ringed worms, which will be described later on. The nervous system of the Sea-urchin consists of a pentagonal ring, surrounding the gullet, and sending five radiating branches along the five ambulacral areas. The reproductive organs are in the form of five membranous sacs, placed in the inter-ambulacral areas, and opening at the genital plates. The young *Echinus* is at first a free-swimming ciliated organism, bilaterally symmetrical, and so unlike the adult that, in its later stages, it was described as a distinct animal, under the name of *Pluteus*. The extraordinary point, however, about its development is, that the young *Echinus* is developed out of only a *portion* of the *Pluteus*, the greater part of which is cast away as useless.

The majority of Sea-urchins are found at moderate depths in the sea, especially in the neighbourhood of oyster-banks. Others spend their existence buried in the sand, and one species excavates holes for itself in the solid rock.

ORDER II. ASTEROIDEA.—Having described the anatomy of the Sea-urchins pretty freely, it will not be necessary to do more than very briefly indicate the more important characters of the remaining orders. The order *Asteroidea* comprises only the true Star-fishes, which consist of a central disc surrounded by a number of rays or arms, which are generally five in number, but may be considerably more numerous. The arms are direct prolongations of the body (fig. 27), contain prolongations of the stomach, and are deeply grooved on their under surface for the radiating vessels of the water-vascular or ambulacral system.

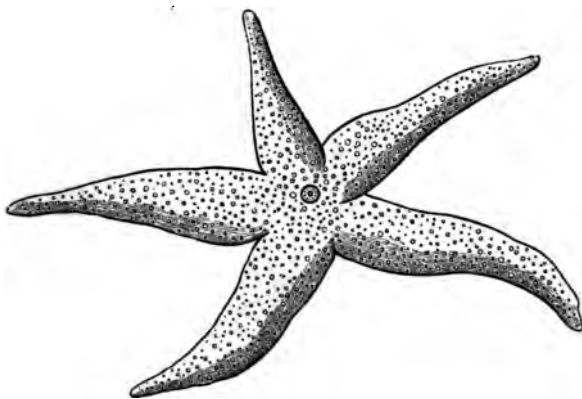


Fig. 27.—*Cribella oculata* (after Forbes).

In their internal anatomy, the Star-fishes do not differ very much from the Sea-urchins. The body, however, is now no longer encased in an immovable box formed of calcareous plates firmly joined together, but the skin is of a leathery nature, and is furnished with an enormous number of little detached grains, plates, and spines of carbonate of lime. Locomotion is effected much as in the Sea-urchins; but the ambulacral tube-feet are arranged in rows, in grooves which run along the under surface of each arm and meet at the mouth. On the upper surface is the "madreporiform tubercle" and the vent, when this is present. The mouth is placed in the centre of the lower surface, and is destitute of teeth. From the stomach proceeds a series of much-branched membranous sacs, two of which are prolonged into each of the arms. The nervous sys-

tem and reproductive organs have much the same arrangement as in the Sea-urchins.

The commoner Star-fishes have a small disc with long finger-like rays, which are properly five in number (fig. 27). In the Sun-stars (*Solaster*) the disc is broad, and is furnished with from twelve to fifteen short rays. In the Cushion-stars (*Goniaster*) the body is in the form of a five-angled disc, more or less flattened on both sides, the rays being only indicated by the ambulacral grooves on the lower surface.

ORDER III. OPHIUROIDEA.—The Sand-stars and Brittle-stars compose this order, and are very closely allied to the true Star-fishes, especially in their star-like form. The body (fig. 28)

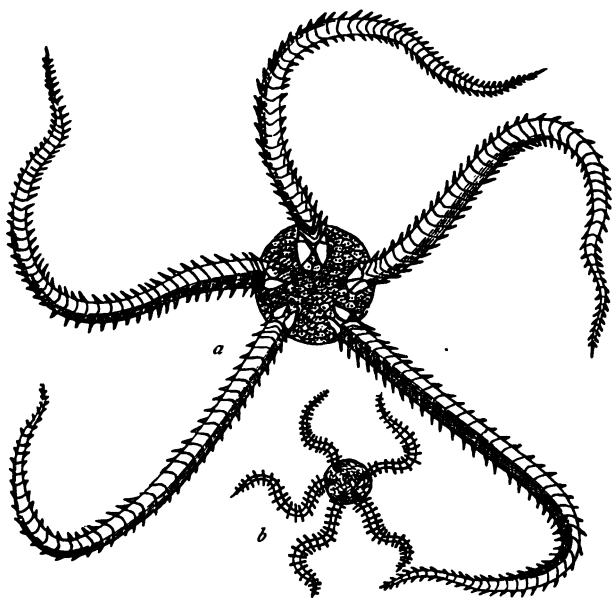


Fig. 28.—*a* *Ophiura texturata*, the common Sand-star; *b* *Ophiocoma neglecta*, the grey Brittle-star. (After Forbes.)

consists of a central disc giving off radiating arms, which are five in number, and may be simple or branched, but which differ from the arms of the true Star-fishes in not containing any prolongations from the stomach, and in not being grooved

for the ambulacral tube-feet. All the internal organs are contained within the disc, and none of them pass into the arms, except the nerve-cords and the ambulacral vessels. The mouth is placed on the under surface of the disc, and conducts into a globular stomach ; but an intestine and vent are wanting.

The habits of the Brittle-stars and Sand-stars are various, but many of them may be found at low water on our own shores, in rock-pools or under stones.

ORDER IV. CRINOIDEA.—The members of this order are distinguished by the fact that they are fixed, during the whole or a portion of the life of the animal, to submarine objects by means of a jointed flexible stalk or column. As an example of this order we may take the Feather-star (*Comatula*), which is found on various parts of our coasts. In its adult state, *Comatula* (fig. 29, *a*) does not differ much in appearance from an or-

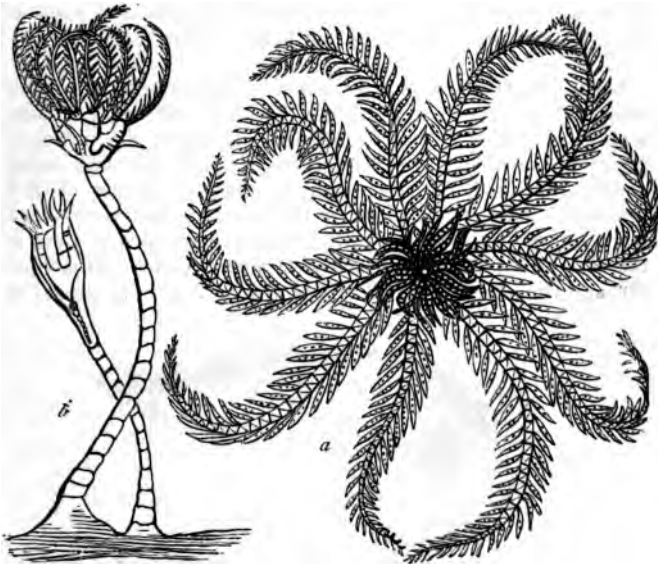


Fig. 29.—*a* Adult *Comatula*; *b* Young *Comatula* supported on its jointed stalk. (After Forbes.)

dinary Star-fish. It consists of a central body or disc, which gives off five arms, which divide directly after their origin into

two branches, so that ultimately ten long and slender arms are produced. The rays carry slender side-arms on both sides, giving the whole arm the feather-like appearance from which the popular name is derived. When young, the *Comatula* differs so much from the adult, that it was originally described as a distinct animal. It consists of a little cup-shaped disc with ten radiating fringed rays, the whole supported on a little jointed stalk, by which it is fixed to some solid object. When sufficiently matured, the body drops off its stalk and develops into the free adult.

The stalked condition, which forms a merely temporary stage in the history of the Feather-star, is the permanent state of parts in a few living forms and in many fossil species. Some of the more beautiful of the fossil *Crinoids* are known as "Stone-lilies," and they are all of great importance geologically, whilst they have some commercial value. Whole beds of limestone, for instance, in more than one formation, are almost wholly made up of the broken stems of fossil *Crinoids*, and many of our ornamental marbles owe their beauty to the same cause.

ORDER V. HOLOTHUROIDEA.—Almost all the members of this order are more or less worm-like in form, and they are commonly known as "Sea-cucumbers." In them, the power of secreting calcareous matter is greatly reduced, the skin being simply furnished with scattered grains and spines of this material. They move about by the alternate contraction and extension of their bodies, by anchor-shaped spicules of lime in the skin, or by ambulacral tube-feet which can be thrust out through the integument. There is always a mouth, placed at

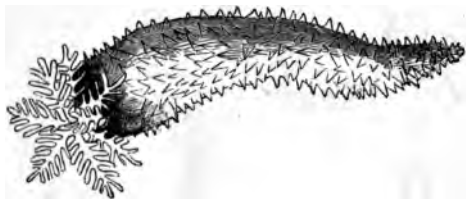


Fig. 30.—*Thyone papillosa*, one of the Sea-cucumbers (after Forbes).

one end of the body, and surrounded by a beautiful circlet of feathery tentacles; and there is always a distinct vent at the opposite end of the body. In most cases the termination of the

alimentary canal is furnished with two much-branched tubes, which are filled with sea-water from without, and are known as the "respiratory tree," as they are believed to act as breathing-organs.

The Holothurians are mostly little known, as they generally live in tolerably deep water. Some of the foreign forms are of a large size, and some are much sought after to supply the Chinese market, being considered a great delicacy in that country.

CHAPTER VII.

CLASS II. SCOLECIDA.

THE *Scolecida* form the second class of the sub-kingdom *Annuloida*, and are characterised by the possession of a water-vascular system of vessels, and a nervous system consisting of no more than one or two ganglia.* They differ from the *Echinodermata* in having no calcareous matter in the skin, and in exhibiting no traces of a radiate arrangement of their organs. Some are worm-like, but others are not, and one whole order is composed of microscopic organisms. Very many live parasitically within other animals, and these are often spoken of collectively as *Entozoa* (Gr. *entos*, within; *zoon*, an animal). These parasitic forms are often very degraded in structure, as they live without exertion on their own part, simply by imbibing the nutritive juices of their host through their delicate integument. The *Scolecida* are divided into the following seven groups or orders :—

1. *Tæniada* (Tape-worms).
2. *Trematoda* (Flukes).
3. *Turbellaria* (Planarians and Ribbon-worms).
4. *Acanthocephala* (Thorn-headed worms).
5. *Gordiacea* (Hair-worms).
6. *Nematoda* (Round-worms).
7. *Rotifera* (Wheel-animalcules).

ORDER I. TÆNIADA.—The family of the Tape-worms may well be illustrated by the commonest of the three Tape-worms of man, the *Tænia solium*. If we commence with the mature animal, we have a flattened tape-like body (fig. 31, 5), often many feet, or even yards, in length, and composed of a number of flattened joints (fig. 31, 4), all loosely united to one another. The entire organism is found inhabiting the alimentary canal

* A *ganglion* is a little mass or knot of nervous matter, containing nerve-cells, and giving origin to nerve-fibres.

of man, and it is not usual to find more than one in the same individual. The worm gradually tapers towards one extremity, till ultimately a point is reached, where the organism is firmly fixed to the mucous lining of the alimentary canal by means of a minute rounded "head" (fig. 31, 3). The "head" attaches itself by means of four suckers and a crown of little hooks of flint. The head contains such nervous organs as exist, and is truly the animal, all the jointed tape-like body which follows it being really produced from the head by budding. The head, however, contains no reproductive organs, and the eggs are produced solely by the flattened joints. The eggs of the Tape-worm cannot be developed in the body of the man who is afflicted with the parasite, but they require to gain

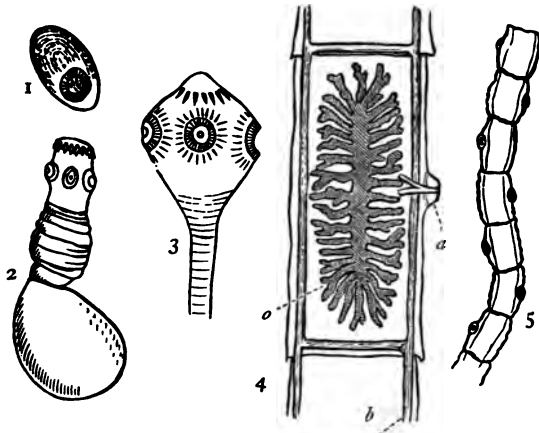


Fig. 31.—1. Egg, containing the young Tape-worm; 2. A bladder-worm, magnified; 3. Head of adult Tape-worm, magnified, showing the hooklets and suckers; 4. A single joint, magnified, to show the branched ovary (*o*) and the water-vascular vessels (*b*); 5. A fragment of *Tania solium*, showing the generative joints.

access to the body of some other warm-blooded animal, in order to develop themselves. To this end the ripe joints of the Tape-worm, laden with eggs, break off, are expelled from the body, and decay. The microscopic eggs, each with a little embryo in its interior (fig. 31, 1) are liberated, to be blown about by the wind or float in water, till they gain some situation where they may be swallowed by a pig. In the stomach of the new host the egg gives exit to a little embryo, which bores its way into the muscles, or into some solid organ, by means of little flinty

spines with which it is provided. It then develops from its hinder end a kind of bladder or cyst filled with fluid (fig. 31, 2), and it constitutes what was formerly called a "cystic worm," under the belief that it was a distinct animal. In this particular case it causes in the pig the disease known as "measles." If now a piece of "measly" pork, containing these little bladder-worms, be eaten by a man, the bladder-worm fixes itself to the mucous membrane of the alimentary canal, throws off its cyst, and becomes at once the "head" of the full-grown tape-worm. It then commences to throw out buds from its hinder end, till ultimately there is produced in *another* individual the same flattened, jointed body with which we originally started.

Similar phenomena are known in other cases, which cannot be noticed here. It is sufficient to mention that man is not only subject to three species of mature tape-worm, but is also liable to the attacks of the bladder-worm, or immature form of at least one other species of tape-worm peculiar to another animal. Thus the disease known to medical men as "hydatids" is caused by the presence of the young or "cystic" forms of the tape-worm of the dog. In England this disease is a rare one; but in some countries, such as Iceland, it is of comparatively common occurrence.

ORDER II. TREMATODA.—The Trematode worms or "Flukes" merely require to be mentioned. They are all internal parasites, and are found inhabiting different situations in various animals, but especially in birds and fishes. They are all more or less flattened and rounded in shape, and they adhere by means

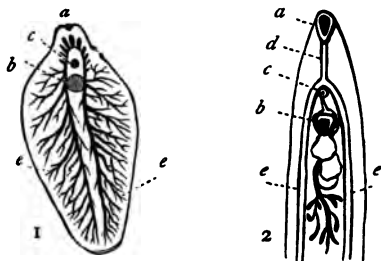


Fig. 32.—1. The Liver-fluke (*Distoma hepaticum*), showing the branched alimentary canal. 2. Anterior extremity of *Distoma lanceolatum*, magnified.

of one or more suckorial discs. The alimentary canal is always merely hollowed out of the body, and is often greatly branched. The most important of the *Trematoda* is the common Liver-fluke

(fig. 32, 1), which is found in the gall-bladder or ducts of the liver in sheep, and is the cause of the disease known as the "rot." It is ovate in shape, flattened on the two sides, and of a yellow colour.

ORDER III. TURBELLARIA.—This order includes the so-called *Planarians* and the Ribbon-worms (*Nemertidæ*). They are never parasitic, and their integument is always furnished with cilia; whilst the alimentary canal may be simple or branched, and may or may not have a distinct vent. The *Planarians* are small jelly-like, soft-bodied, ovate or elliptical creatures, which are commonly found in fresh water, or on the sea-shore, or in moist earth. The *Nemertidans* or Ribbon-worms are commonly found on the sea-shore, and differ from the *Planarians* in their completely worm-like shape.

ORDER IV. ACANTHOCEPHALA.—The "Thorn-headed worms" included in this order are all internal parasites, but they merely require to be mentioned. They are amongst the most formidable parasites with which we are acquainted, and are found inhabiting the alimentary canal in many birds, fishes, and mammals, but not, as far as is yet known, in man. They owe their name to the fact that the anterior end of the body forms a kind of proboscis or snout, which is armed with recurved hooks.

ORDER V. GORDIACEA.—The "Hair-worms" are also of little importance. They are thread-like parasites which spend the earlier part of their existence in the interior of various insects, which they leave in order to lay their eggs. They are singularly like horse-hairs in appearance, and often attain a length many times greater than that of their insect-host.

ORDER VI. NEMATODA.—In this order are the "Round-worms" and "Thread-worms," both of which are internal parasites, together with a number of forms which lead a permanently free existence. They have all a rounded worm-like shape, and possess a distinct mouth, a freely-suspended alimentary canal, and a vent. The most important of the parasitic forms are the common Round-worm (*Ascaris*) and the Thread-worm (*Oxyuris*), both of which inhabit the alimentary canal of the human subject; and the Guinea-worm, which burrows amongst the tissues of man, especially of the legs, and attains a length of several feet. Of the free Nematode worms, the most familiar is the so-called "vinegar-eel" (*Anguillula aceti*).

ORDER VII. ROTIFERA.—The *Rotifera* or “Wheel-animalcules” owe both their scientific and popular name to the fact that the anterior end of the body is almost always furnished with one or two circlets of cilia (fig. 33), which, when in motion, vibrate so rapidly as to produce the illusory impression of a quickly-rotating toothed wheel. They are all microscopic in size, and are mostly to be found inhabiting collections of fresh water. They are generally free-swimming active little creatures (fig. 33, A), but some of them are permanently fixed (fig. 33, B). The males and females mostly differ very greatly from one another, the males being much smaller than the females, devoid of the most important of the internal vital organs, and living a merely transitory existence, the sole end of which is to fertilise the eggs of the female.

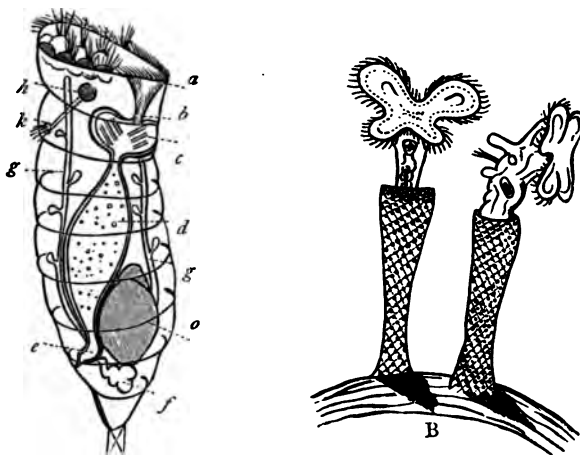


Fig. 33.—Diagram of a Rotifer (*Hydatina*). *a* Depression in the ciliated disc leading to the mouth (*b*); *d* Stomach; *g g* Water-vascular tubes; *h* Nerve-ganglion; *e* Ovary. B, Builder-animalcule (*Melicerta*). After Gosse.

The free-swimming forms are propelled through the water by the cilia of the disc, which likewise bring particles of food to the mouth. The mouth generally opens into a wide muscular chamber, containing a complicated apparatus of horny teeth, and this opens into a capacious stomach. Connected with the termination of the intestine, by means of a little contractile sac or bladder, are two tubes (*g g*) which belong to the water-vascular system, and are known as the “respiratory tubes.” The

nervous system consists of a double ganglion placed above the gullet, and having one or two eye-specks placed upon it.

The *Rotifera* were long confounded with the Infusorian animalcules, from the resemblance in external appearance between the two. The *Rotifera*, however, are of a much higher grade of organisation, as shown by their having a distinct nervous system, body-cavity, and generally an alimentary canal, which communicates with the outer world only by the mouth and vent.

TABLE OF THE DIVISIONS OF THE ANNULOIDA.

CLASS I. ECHINODERMATA.—Integument more or less charged with lime, or leathery. A water-vascular system, which usually assists in locomotion, and usually communicates with the exterior. Adult more or less distinctly radiate.

Order 1. *Crinoidea*.—*Ex.* Feather-star (Comatula).

Order 2. *Blastoidea* (extinct).

Order 3. *Cystoidea* (extinct).

Order 4. *Ophiuroidea*.—*Ex.* Brittle-stars and Sand-stars.

Order 5. *Asteroidea*.—*Ex.* Star-fishes.

Order 6. *Echinoidea*.—*Ex.* Sea-urchins.

Order 7. *Holothuroidea*.—*Ex.* Sea-cucumbers.

CLASS II. SCOLECIDA.—Usually flattened or cylindrical; soft-bodied; water-vascular system not assisting in locomotion; nervous system not arranged in a radiating manner, and consisting of one or two ganglia.

Order 1. *Taniada*.—*Ex.* Tape-worms.

Order 2. *Trematoda*.—*Ex.* Flukes.

Order 3. *Turbellaria*.—*Ex.* Planarians.

Order 4. *Acanthocephala*.—*Ex.* Echinorhynchus.

Order 5. *Gordiacea*.—*Ex.* Hair-worms.

Order 6. *Nematoda*.—*Ex.* Round-worms.

Order 7. *Rotifera*.—*Ex.* Wheel-animalcules.

SUB-KINGDOM IV.—ANNULOSA.

CHAPTER VIII.

ANARTHROPODA.

SUB-KINGDOM ANNULOSA.—In this sub-kingdom are comprised an enormous number of animals, which agree in the following characters (fig. 34). The body is composed of a number of segments or rings arranged longitudinally, one behind the other. There is a distinct alimentary canal, which is completely shut off from the general cavity of the body. The blood-circu-

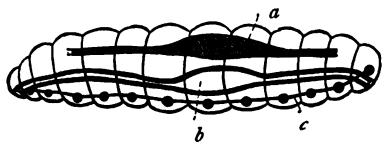


Fig. 34.—Diagram of an Annulose animal. *a* Blood-circulatory system; *b* Alimentary canal; *c* Nervous system.

latory system is not always developed, but its central organ (or heart), when present, is always placed on the dorsal aspect of the body (*a*). The nervous system is placed ventrally, or on the opposite side of the digestive canal to the chief organ of the circulation, and consists typically of a chain of ganglia. A pair of ganglia properly belongs to each segment, and the first pair is placed above the gullet, and the second below, so that the gullet is embraced by a nervous ring or collar. The limbs (when present) are always turned towards that side of the body on which the main masses of the nervous system are placed.

The sub-kingdom *Annulosa* is divided into two great divisions, according as the body is furnished with jointed appendages or not. The former of these is termed *Arthropoda* (Gr. *arthros*, a joint; *pous*, foot), and comprises the Crustaceans, Spiders and

Scorpions, Centipedes and Insects. In the *Anarthropoda* (Gr. *a*, without; *arthros*, joint; *pous*, foot), in which the body is destitute of jointed appendages, are included the Spoon-worms and their allies (*Gephyrea*), the singular marine animals known as *Sagitta*, and the Ringed worms (*Annelida*). Of these, the *Annelida* alone are of sufficient importance to justify their being considered here.

CLASS ANNELIDA.—The body in the Ringed worms is composed of a number of rings which are all similar to one another, except at the two ends of the body; hence both the scientific and popular names of the group. The class includes the Leeches, Earth-worms, Tube-worms, and Sand-worms, all of which are more or less worm-like in shape, and all of which (with the exception of the Leeches) have lateral appendages, which, however, are never jointed to the body. In the higher forms each ring or segment (fig. 35) consists of two arches, an

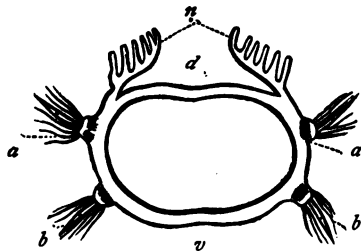


Fig. 35.—Diagram of a ring of an Annelide. *d* Dorsal arc; *v* Ventral arc; *n* Branchiæ or gills; *a* Dorsal oar; *b* Ventral oar, both carrying bristles and a jointed filament.

upper and lower, termed respectively the "dorsal arc" (*d*), and "ventral arc" (*v*). The lateral appendages are known as "foot-tubercles," and may consist of two pieces, an upper process or "dorsal oar" (*a*), and a lower or "ventral" piece (*b*), both carrying a tuft of bristles and a soft jointed filament. The nervous and digestive systems have the same structure as is characteristic of the Annulose sub-kingdom. There is, however, no distinctly developed blood-circulatory system, the blood being believed to be represented by a fluid, with solid particles in it, which fills the body-cavity. There is, however, a peculiar system of vessels, which are contractile, contain a fluid with solid particles, and send branches to the breathing-organs, when these exist. This system is believed to correspond to the water-

vascular system of the *Annuloida*, and not to the blood-vessels of the higher animals, and it is, therefore, termed the "pseudo-hæmal" system (Gr. *pseudos*, false; *haima*, blood). Respiration is sometimes effected by the general surface of the body, assisted, probably, by certain peculiar pouches (the so-called "segmental organs"); but in other cases there are distinct gills or *branchia*—that is, organs adapted for breathing air dissolved in water.

The class *Annelida* is divided into the four orders of the *Hirudinea* (Leeches), *Oligochata* (Earth-worms), *Tubicola* (Tube-worms), and *Errantia* (Sand-worms), each of which may be briefly noticed.

ORDER I. HIRUDINEA.—The order *Hirudinea* (Lat. *hirudo*, a horse-leech) comprises only the Leeches, of which some inhabit the sea, whilst others live in fresh water. They are characterised by the fact that the body is not provided with lateral appendages of any kind, but is furnished with a sucker or disc at one end only or at both extremities (fig. 36). They swim by means of a serpentine bending of the body, or crawl about by alternately fixing and detaching the suckers, much after the manner of progression in the common "Looper" caterpillars.

The most familiar of the Leeches are the common Horse-leech (*Hæmopsis*) and the Medicinal Leech. The former of these occurs abundantly in this country, but is of no commercial value, as it is destitute of teeth. The Medicinal Leech owes its value to the fact that the mouth is furnished with three semicircular toothed jaws (fig. 36, *b*, *c*) which meet in a point, and are sufficiently strong to saw through the skin. It is of rare occurrence in this country, but occurs abundantly in the south and east of Europe, and is largely imported from Hungary, Bohemia, and Russia.

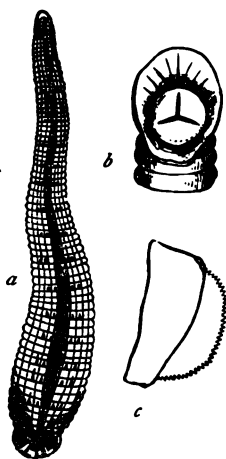


Fig. 36.—*a* Medicinal Leech (*Sanguisuga officinalis*); *b* Anterior extremity of the same, showing the sucker; *c* One of the jaws detached.

ORDER II. OLIGOCHÆTA. — The order *Oligochæta* (Gr. *oligos*, few; and *chaîtê*, bristle) is well exemplified by the common Earth-worm (*Lumbricus terrestris*). The entire order is characterised by the fact that the body is furnished with rows of bristles, which

act as organs of locomotion. The bristles are comparatively few in number, and are not supported upon "foot-tubercles," as in the higher Annelides. In the common Earth-worm eight rows of these locomotive bristles are present; but the animal is too well known to require description.

ORDER III. TUBICOLA.—The order *Tubicola* (Lat. *tuba*, a tube; and *colo*, I inhabit) owes its name to the fact that the animals belonging to it have the power of protecting themselves within tubes (fig. 37). In some cases the investing tube is composed of carbonate of lime, but in other cases it is constructed of particles of sand or fragments of shell agglutinated together. Unlike the Annelides of the two preceding orders, the *Tubicola* possess special breathing-organs in the form of filamentary gills or "branchiæ," in which the fluid of the pseudohæmal system is exposed to the action of the outer water. The gills, however, are placed only on or near the head, as it is only this portion of the body which is naturally protruded from the investing tube.

Amongst the most familiar examples of the *Tubicola* may be mentioned the *Serpulæ* (fig. 37, *a*), the winding and contorted calcareous tubes of which must be known to every visitor at the sea-side. Equally common is the little *Spirorbis* (fig. 37, *b*), in which the tube is coiled up into a flat spiral, and is cemented by one side to the fronds of sea-weed or to some other solid object.

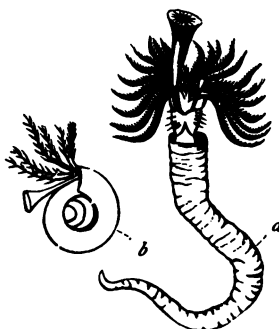


Fig. 37. — *a* *Serpula contortuplicata*, showing the feathery gills attached to the head; *b* *Spirorbis communis*.

ORDER IV. ERRANTIA.—The "Errant" Annelides (Lat. *erro*, I wander) are so called because they lead a free existence, and are not confined in tubes. Like the preceding, they breathe by means of gills, and these organs, to suit their mode of life, are placed in tufts along the back or sides of the body. The organs of locomotion consist of lateral unjointed appendages or "foot-tubercles," which carry tufts of bristles. The anterior rings of the body are generally so modified as to form a sort of head, which is provided with eyes and with two or more unjointed feelers.

Amongst the best known of the Errant Annelides is the Lob-worm (*Arenicola piscatorium*), which burrows in the sand of all our coasts, and is largely used by fishermen for bait. Equally familiarly known, though not generally recognised as

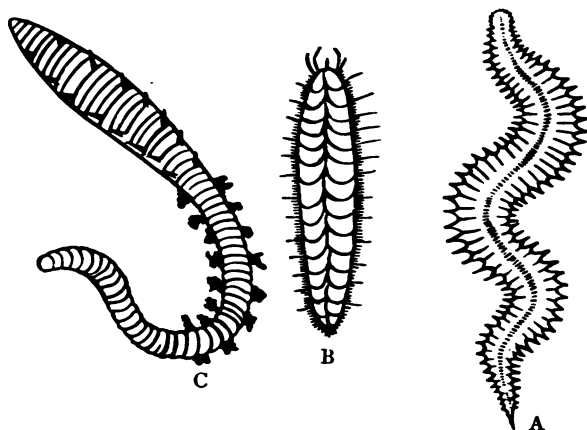


Fig. 38.—A. *Nephtys*; B. *Aphrodite*; C. *Arenicola piscatorium*.
(After Gosse.)

a Ringed worm, is the Sea-mouse (*Aphrodite aculeata*), which attains a large size, and is remarkable for its beautiful iridescent bristles. Many other common forms may be found by searching under stones at low water.

CHAPTER IX.

ARTHROPODA.

I. GENERAL CHARACTERS OF THE ARTHROPODA.

2. CHARACTERS OF THE CRUSTACEANS.

DIVISION ARTHROPODA OR ARTICULATA.—The members of the sub-kingdom *Annulosa* comprised under this head are generally known as *Articulata* (Lat. *articulus*, a joint) or *Arthropoda* (Gr. *arthros*, a joint; and *pous*, foot), since they are provided with *jointed appendages, articulated to the body*. Besides the above and the characters which they share with all the *Annulosa*, the *Articulata* animals have one or two other peculiarities which are eminently characteristic of them. Thus the body is composed of a number of distinct rings or segments, arranged longitudinally one behind the other, and often extremely definite in number. It is only in a few forms, also, that the segments present any great resemblance to one another over the greater part of the body; and even in these some of the segments of the anterior end of the body constitute what is at once recognisable as the head. The skin, further, is almost always more or less completely hardened by the deposition in it of a horny substance, often with the addition of lime, so that it forms a strong hollow shell, to the inner surface of which the muscles are attached. There is, therefore, no necessity for any internal skeleton. Lastly, as a rule, the limbs are also hollow, and have the muscles attached to their interior.

The *Arthropoda* are divided into four great classes—viz., the *Crustacea* (crabs, lobsters, &c.), the *Arachnida* (mites, spiders, and scorpions), the *Myriapoda* (centipedes and millipedes), and the *Insecta* (or true insects).

CLASS I. CRUSTACEA.—The great class of the *Crustacea*, comprising Crabs, Lobsters, King-crabs, and numerous other allied forms, is distinguished from the remaining three classes of the *Arthropoda* by the fact that its members are all adapted for a

more or less aquatic life, living either in water or in moist places. In accordance with this peculiarity, whenever the Crustaceans have distinct breathing-organs, these are in the form of gills or "branchiæ," adapted for breathing air dissolved in water. Besides this leading character, Crustaceous animals are further distinguished by mostly having more than four pairs of legs, by carrying jointed appendages on the hinder extremity of the body (abdomen), and by having two pairs of jointed feelers or "antennæ."

The class *Crustacea* includes such a large number of animals, of such very varied appearance and structure, that it will be sufficient here to notice shortly some of the more important and characteristic forms.

The Lobster (fig. 39) is a very readily obtainable example, and will illustrate the leading points of interest in the order. If we look at the Lobster, we see at once that it is made up of two parts which we should call familiarly the "head" and the "tail." The so-called "head" is really composed of the segments of the head proper, and of the chest (thorax), and is covered by a great plate or shield, which is termed the "carapace" (fig. 39, *ca*). Behind the carapace comes the "tail," or, as it is scientifically called, the "abdomen," which is composed of a number of rings movably jointed together. From the possession of a long and movable abdomen, the Lobster is placed in a tribe of Crustacea called *Macrura* (Gr. *makros*, long; *oura*, tail). Each segment of the abdomen carries a pair of oar-like appendages, used in swimming, and called "swimmerets," and the last pair is greatly dilated, and forms a powerful swimming-paddle. There are five pairs of legs used in progression, and for this reason the Lobster is placed in an order of the *Crustacea* called *Decapoda* (Gr. *deka*, ten; *pous*, foot). The first three pairs of these legs are furnished at their ends with nipping-claws, of which the hinder two pairs are very small; but the first pair is greatly developed, and constitutes the great claws. On the under surface of the head is the mouth, surrounded by a complicated series of modified appendages used in masticating and cutting the food. The last pairs of these appendages are so little altered from ordinary limbs, that they are known as foot-jaws. The head also carries the eyes and two pairs of feelers or "antennæ," a small pair (*a*) and a long pair (*ga*). The eyes are supported upon long and movable stalks, and for this reason the Lobster is placed in a division of the *Crustacea*, to which the name of *Podophthalmata* is given (Gr. *pous*, foot; and *ophthalmos*, eye).

The digestive system of the Lobster consists of a mouth, gullet, globular stomach, and intestine, terminating in a distinct vent. There is also a well-developed liver. The heart is placed on the back (dorsally), and respiration is carried on by

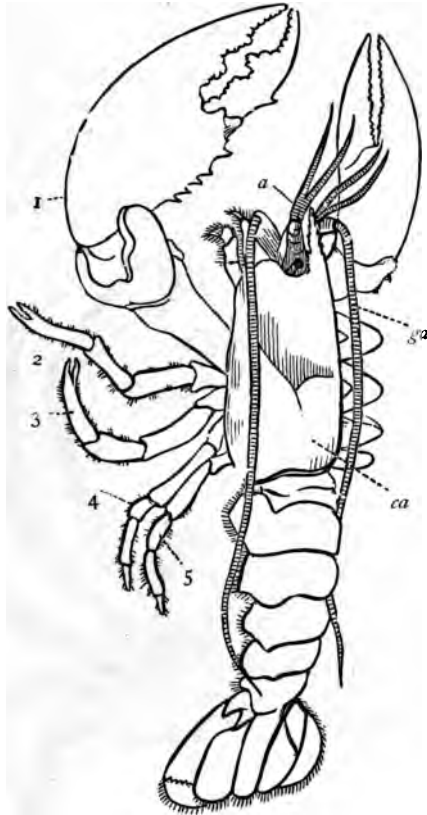


Fig. 39.—Common Lobster (*Homarus vulgaris*). 1. First pair of legs, constituting the great nipping-claws; 2 and 3. Second and third pairs of legs, also ending in nipping-claws; 4 and 5. Last two pairs of legs; *a* Smaller antennæ; *ga* Greater antennæ; *ca* Carapace.

means of a number of pyramidal gills or branchiæ attached to the bases of the legs, and placed in a kind of chamber formed beneath the great shield or carapace on each side of the body.

The water which fills the gill-chambers is constantly renewed by the movements of the legs, and thus the gills are kept continually supplied with fresh water.

Nearly allied to the Lobster, and very similar in essential structure, are the Cray-fish, the Shrimp, the Prawn, and other less familiar forms. Also nearly related to the "Long-tailed Crustaceans" are the Hermit-crabs and their allies. In the Hermits the "tail" or abdomen is still well developed, but it is quite soft, and is not protected by any shell. The animal, therefore, protects this part of its body by appropriating the empty shell of some Mollusc, such as the Periwinkle or Whelk, and he changes his borrowed dwelling whenever it becomes inconveniently small for him.

The remaining group of the "decapodous" or ten-footed

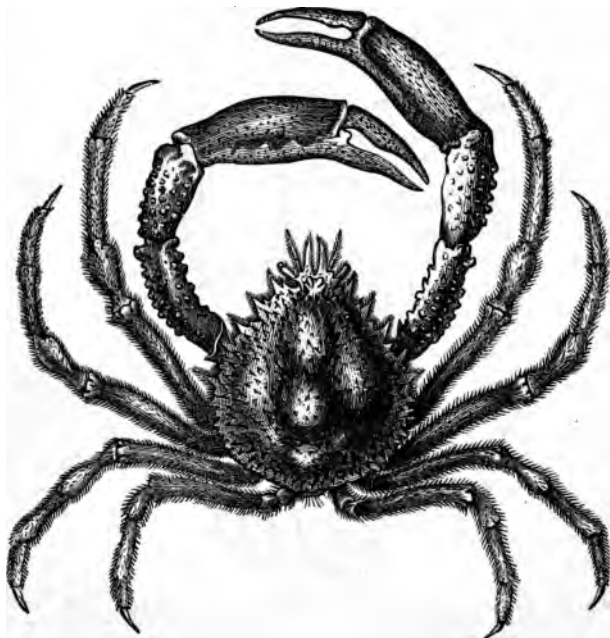


Fig. 40.—The Spiny Spider-Crab (*Maia squinado*).

Crustaceans is constituted by the Crabs (fig. 40). These are placed in a tribe called *Brachyura* (Gr. *brachus*, short; *oura*, tail), in consequence of the rudimentary condition of the "tail"

or abdomen. In fact, not only is the abdomen quite rudimentary, but it is completely tucked away out of sight; so that when the animal is looked at from above, nothing is visible except the great shield or carapace. As in the Lobster and the Hermit-crabs, the eyes of the crabs are supported upon moveable stalks, so that these, too, belong to the division of the *Podophthalmata*. Most of the crabs live between tidemarks, or in shallow water; but the so-called "Land-crabs" live habitually on shore, and sometimes even far inland.

Another group of Crustaceous animals, called *Isopoda* (Gr. *isos*, equal; *pous*, foot), is represented by the common Wood-lice (fig. 41), so well known as occurring in crevices of old walls, or under stones. Though the Wood-lice live inland, they always affect moist places, and their breathing-organs con-

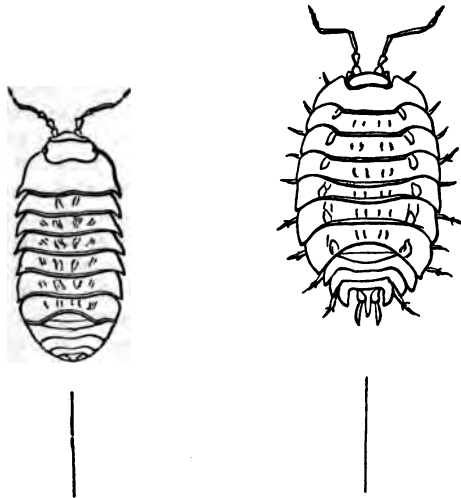


Fig. 41.—Wood-lice (*Oniscus*).

sist of gills or branchiæ; whilst they are related to other forms which live habitually in water. They differ from the preceding Crustaceans in not having their eyes supported upon stalks, and they are, therefore, referred to a division called *Edriophthalmata* (Gr. *hedraios*, sitting; *ophthalmos*, eye).

The King-crabs represent another order of *Crustacea* called *Xiphosura* (Gr. *xiphos*, a sword; *oura*, tail), from the fact that the end of the abdomen is furnished with a long sword-like spine (fig. 42). The whole of the upper surface of the body in

these Crustaceans is protected by a kind of buckler, and in the centre of the lower surface is the mouth, surrounded by six pairs of appendages, the bases of which act as jaws, whilst their extremities form pincers or nipping-claws. The King-crabs often attain a very large size, and are sometimes called "Molucca Crabs." Both the eggs and the flesh are eaten by the Malays.



Fig. 42.—King-crab (*Limulus polyphemus*) viewed from below.

Less familiar than any of the preceding are many very minute Crustaceans, belonging to several different orders, but familiarly known as "Water-fleas" (fig. 43). Subjoined is an illustration of some of these diminutive organisms, which swarm in countless myriads in most of our ponds in summer-time. Many also occur in the sea, and some of them are of great geological importance, their minute shells sometimes making up the greater part of even extensive formations.

The last group of the Crustaceans which need be noticed here,

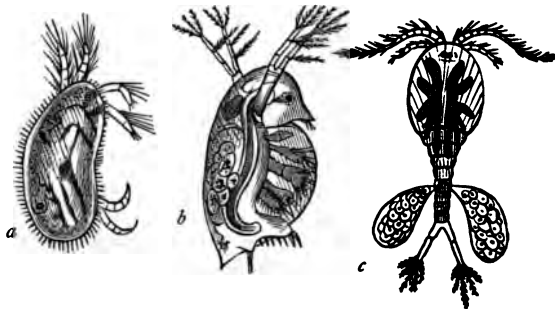


Fig. 43.—Water-fleas. *a* Cypris; *b* Daphnia; *c* Cyclops.

is that of the *Cirripedia* (Lat. *cirrus*, a curl; *pes*, foot), compris-

ing the so-called Barnacles and Acorn-shells, both very unlike Crustaceans to look at. They are distinguished by the fact that whilst they are free-swimming little creatures in their young condition, when adult they are immovably fixed by their heads to some solid object. In this fixed condition, as a rule, the internal organs are protected by a calcareous shell, composed of many pieces; and the only parts of the body which remain movable are the legs, which are constantly thrust out of the shell and again drawn in in quest of food.

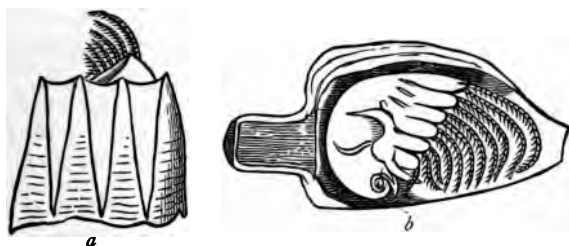


Fig. 44.—*a* Acorn-shell (*Balanus*); *b* Barnacle (*Lepas*).

The Acorn-shells (*Balanus*) occur in myriads upon every solid object between tide-marks. In these (fig. 44, *a*) the head is fixed to the centre of a membranous or shelly plate, and the body is protected by a limpet-shaped shell, composed of several pieces, and having an opening at its summit. This opening is closed by a movable lid, and from it the animal can protrude its legs, which are constantly employed, like a little sweeping-net, in search of food.

In the Barnacles (fig. 44, *b*), on the other hand, the anterior end of the body is much lengthened, and forms a kind of stalk by which the animal is attached to some solid object, such as a rock, a floating log of timber, the side of a ship, or even some marine animal.

CHAPTER X.

CLASS II. ARACHNIDA.

THIS class includes the Mites, Ticks, Scorpions, and Spiders, and is, as a whole, very nearly related to the *Crustacea*. The *Arachnidans*, however, are all air-breathers, so that when they have any distinct breathing-organs, they are never in the form of gills, but are always either air-sacs (*pulmonary sacs*) or breathing-tubes (*tracheæ*), or both combined. In none of the *Arachnida*, further, are there ever more than *four pairs of legs*; and the rings which compose the tail or "abdomen" never carry any limbs of any kind whatever. The eyes are always "sessile," that is to say, they are not supported upon stalks; and if antennæ exist, only one pair is present, and these are much modified, and do not act as feelers. Lastly, the head is always amalgamated with the chest (thorax), so as to form a single mass, which is termed the "cephalothorax."

Amongst the lower forms of the *Arachnida* are many small animals, of which the most important are the Sea-spiders and the Mites. The Sea-spiders (fig. 45, *a*) are inhabitants of the

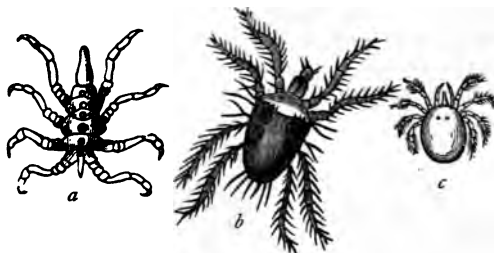


Fig. 45. — *a* Sea-spider (*Pycnogonum*); *b* Sociable mite (*Tetranychus*); *c* Water-mite (*Hydrachna*).

sea, and they are very often referred to the *Crustacea*. They are all very long-legged, some of them extraordinarily so, and

in some cases the legs contain prolongations from the stomach. They are all grotesque-looking creatures, which may be found at low water upon stones or marine plants, or which are attached parasitically to marine animals.

The Mites (fig. 45, *b*, *c*) form with the Ticks the order *Acarina*, and are distinguished by the fact that the abdomen is amalgamated with the cephalothorax to form a single mass. The Mites are all minute animals, the habits of which are very various. Some are found upon various plants (fig. 45, *b*); others are parasitic upon water insects when young, but swim about freely in the water when adult; others live permanently as parasites upon other animals, such as insects; and others inhabit decaying provisions, as is the case with the well-known "Cheese-mite."

Amongst the largest and most formidable of the *Arachnida* are the Scorpions, which form the order *Pedipalpi*. They are characterised by having a distinctly segmented abdomen, which passes into the cephalothorax, without any well-marked line of boundary (fig. 46). The last joint of the tail or abdomen is hooked, and is perforated by a tube leading down to a poison-

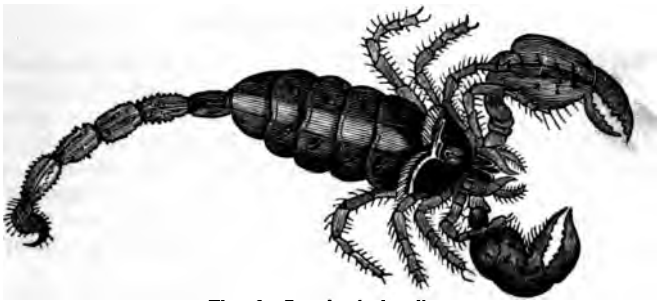


Fig. 46.—Scorpion (reduced).

gland at its base. It is by means of this that the Scorpions "sting," and the wounds inflicted by the larger species are not only extremely painful, but in some cases are actually dangerous to life. The feelers (antennæ) of the Scorpions constitute small nipping-claws, and two of the appendages of the mouth are developed into great pincers; but these are not capable of inflicting injury on man. The process of respiration is carried on by four pairs of chambers or "pulmonary sacs," which open on the surface, and thus obtain air, by means of distinct apertures placed on the under surface of the abdomen. The Scor-

pions live in the warmer parts of the temperate zone and in tropical regions, and are generally found hiding under stones or in the crevices of walls. They are much, and justly, dreaded by the inhabitants of the countries in which they occur.

The last of the *Arachnida* which need be noticed are the true Spiders or *Araneida*. The spiders are very commonly confounded with the insects, but they are at once distinguished by having four pairs of legs (fig. 47), by not having the abdomen distinctly ringed, and by having the head and thorax



Fig. 47.—*Theridion riparium* (female).

amalgamated into a "cephalothorax." They are distinguished from the scorpions by having the abdomen distinctly marked off from the thorax, and only joined to it by a narrow stalk. Like the scorpions, the spiders breathe by means of "pulmonary sacs;" but, in addition to these, they possess air-tubes or "tracheæ." These are branching tubes which open externally by distinct apertures, and carry air to all parts of the body, their membranous walls being kept from collapsing by a horny filament which is coiled up in their interior.

From their rapacity and their general repulsiveness of appearance, the spiders are not such popular objects of study as the insects; but they nevertheless present many points of great interest, which cannot be touched upon here. They are all "carnivorous," living upon other animals, and many of them possess the power of constructing webs, which they employ either in the capture of their prey or in the construction of their own habitations. The material of which the web is made is the secretion of a special gland, and it is moulded to its proper shape by being passed through certain conical little organs which are placed at the extremity of the abdomen, and are termed the "spinnerets."

CHAPTER XI.

CLASS III. MYRIAPODA.

THE third class of the *Arthropoda* is that of the *Myriapoda* (Gr. *muria*, ten thousand; *pous*, foot), and is a very small one, including only the Centipedes and Millipedes and their allies. They are distinguished from both the preceding classes and from the Insects by the following characters:—*The head and chest (thorax) are distinct from one another, but the thorax and abdomen are not separated by any boundary-line*, the segments of the two being nearly similar (fig. 48). The body always consists of more than twenty rings, and *the hinder segments, which correspond to the abdomen, always carry locomotive limbs*. There is one pair of antennæ, the number of legs is not *definite*, and the breathing-organs are in the form of air-tubes (tracheæ).

The Centipedes (fig. 48) are familiarly known in the person of a very common British species, which is of small size, and, though not attractive in appearance, is perfectly harmless. Some of the tropical forms, however, attain a length of several inches, and are able to inflict a very severe or even dangerous bite. This they effect by means of hooked "foot-jaws," which are perforated for the discharge of a poisonous fluid. The Centipedes, therefore, *bite*, and do not *sting*, as do the Scorpions. They are further characterised by the fact that the number of legs is not indefinitely great (usually from fifteen to twenty pairs), and the feelers or antennæ have not less than fourteen joints each.



Fig. 48.—Centipede (*Scolopendra*), (after Jones).

The Millipedes (fig. 49) are even more repulsive in appearance than the Centipedes, but they are quite harmless, and



Fig. 49.—Millipede (*Iulus*).

live principally upon decaying vegetable matter, whereas the latter are animal-feeders. The body is rounded and worm-like, and is supported by an indefinitely great number of minute thread-like legs. The feelers or antennæ, further, are short, and have only six or seven joints each. The British Millipedes are of small size, but a South American species attains a length of several inches.

CHAPTER XII.

CLASS IV. INSECTA.

THE true Insects (Lat. *inseco*, I cut into) are the best known and most popular of Articulate animals, though commonly many other creatures, such as Spiders, Mites, Centipedes, and others, are loosely included under this head. The true *Insecta* are distinguished from the preceding classes of Articulate animals by the fact that *the three divisions of the body—the head, thorax, and abdomen—are always distinct from one another in the adult animal; there are never more than three pairs of legs in the adult, and these are carried by the three rings of the thorax; the abdomen of the mature insect never carries any locomotive appendages.* Respiration is effected by means of “air-tubes” or “tracheæ,” and in most insects two pairs of wings are developed upon the second and third segments of the thorax.

The skin of insects is more or less hardened by the deposition in it of a horny matter, and the body is deeply cut into segments. The head is always distinctly marked (fig. 50), and carries a pair of jointed feelers or “antennæ,” a pair of eyes, and the appendages of the mouth. The antennæ are certainly used as organs of touch, but they appear to be the organs of other higher senses, of which it is not impossible that hearing is one. The eyes are almost always what is called “compound”—that is to say, they are composed of a great number of simple eyes, each perfect in itself, and placed side by side. The organs of the mouth are very complicated, and adapt the Insect for biting hard substances, for sucking up fluids, or for both together. The thorax in Insects (fig. 50, *b, c, d*) consists of three rings, which are more or less completely amalgamated, but are generally pretty easily recognised. In adult Insects each of these rings carries a pair of jointed legs, so that there are three pairs of legs in all. In most Insects, also, the two hinder segments of the thorax carry each a pair of wings, in the form of membranous expansions, strengthened by hollow tubes or “ner-

vures. Either of these two pairs of wings, however, may be absent; or both may be absent or rudimentary; or, lastly, the front pair may be hardened so as to be useless in flight, but to

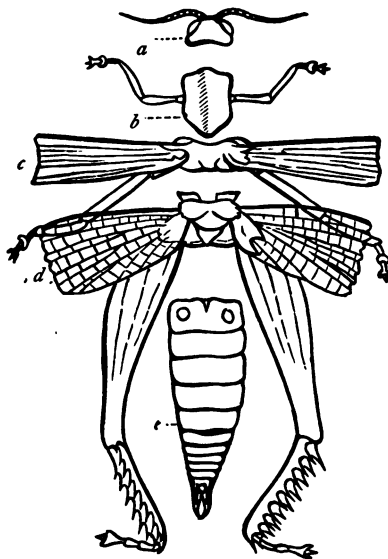


Fig. 50.—Diagram of the external anatomy of an Insect. *a* Head, carrying the eyes and antennæ; *b* First ring of the thorax, carrying the first pair of legs; *c* Second segment of the thorax, carrying the second pair of legs and the first pair of wings; *d* Third segment of the thorax, carrying the third pair of legs and the second pair of wings; *e* Abdomen, without limbs, but carrying appendages concerned in reproduction.

form protective cases for the hinder wings. The abdomen of Insects (fig. 50, *e*) is composed of several segments, which are more or less freely movable on one another, but which never carry locomotive limbs, as is so commonly the case with the *Crustacea*. The last segments of the abdomen, however, often carry appendages, which are primarily connected with reproduction, but which are often converted into weapons of offence and defence. Of this nature are the stings of bees and wasps, the forceps of the common Earwig, and the "ovipositors" of Saw-flies and many other Insects.

As regards the internal anatomy of Insects, little need be said here.

There is a complete alimentary canal, usually with accessory glands, supposed to represent the salivary glands, liver, and kidneys of higher animals. The circulation is carried on mainly by a long contractile tube, placed along the back, and known as the "dorsal vessel." Respiration is effected by means of branched air-tubes or "tracheæ," which commence at the surface by minute apertures, and then proceed inwards, branching as they go, so that every part of the body is richly supplied with air. The nervous system has the regular *Annulose* type, consisting essentially of a chain of little nervous masses or ganglia, united by cords, and placed along the lower or ventral surface of the body.

The sexes in Insects are distinct, and most of them lay eggs (or are "oviparous"). In some of the lower orders of the Insects, the young, on escaping from the egg, resemble the adult in everything except in size, and they undergo no alteration in reaching maturity, except that they grow larger. All the Insects in which this occurs are destitute of wings when fully grown. For this reason they are often called *Aptera* (Gr. *a*, without; *pteron*, a wing). In all other Insects the adult is furnished with wings (with a few unimportant exceptions), and the young passes through a series of changes, known as the "metamorphosis," before maturity. The young Insect, on leaving the egg, is known as the "*larva*" (Lat. *larva*, a mask), and in most cases it constitutes what would popularly be called a "caterpillar" or a "grub." In this state it is not only much smaller than the adult, but is destitute of wings, and is often furnished with organs which are either not present at all in the adult or are quite rudimentary, and which enable it to lead a life quite different to that of the fully-grown Insect. After several changes of skin, the "*larva*" passes into the second stage, when it is known as the "*pupa*" (Lat. *pupa*, a doll). After remaining a longer or shorter time in this second stage, the Insect passes into the third and final stage, that of the perfect Insect, when it is known as the "*imago*" (Lat. *imago*, an apparition). The "*pupa*," however, varies considerably in its characters in different Insects, and upon these differences important divisions of Insects have been founded. In some cases the "*pupa*" is quite active and locomotive, and differs from the larva only in being bigger and in possessing rudimentary wings. In order to convert it into the adult or "*imago*," therefore, nothing further is necessary than that the pupa should grow, and that its wings should be fully developed. In all Insects in which this occurs—such as Grasshoppers, Dragonflies, &c.—the metamorphosis is said to be "incomplete." In other cases, however, the "*pupa*" (fig. 51) differs very much from both the larva and the adult insect or "*imago*," and the metamorphosis is said to be "complete." The best example of this kind of metamorphosis is to be found in the Butterflies and Moths (*Lepidoptera*). In these Insects the "*larva*" is worm-like, and constitutes what every one knows as a "caterpillar." It now possesses a horny head, with masticating organs, adapting it for eating solid food, and with little glands, the function of which is to secrete silk. It likewise possesses a variable number of soft, fleshy, temporary feet, which are placed in the hinder part of the body, and which do not correspond with the

three pairs of legs proper to the adult, these being present as well. Having remained in this condition for a longer or shorter



Fig. 51.—Metamorphosis of the Magpie-moth (*Phalena grossulariata*).

time, and having cast its skin repeatedly, so as to allow for its rapid growth, the larva passes into the second stage and becomes a "pupa." It constitutes now what is called the "chrysalis," and is quite quiescent, unless irritated, being usually buried in the ground or attached to some foreign object, and being, therefore, incapable of changing its place. The body is completely covered by a thin horny covering, and in some cases this is still further protected by the dried skin of the larva; whilst in other cases the larva, immediately before entering the pupa-stage, spins for itself a case of silken threads, which surrounds

the chrysalis, and is known as the "cocoon." Ultimately, the horny envelope of the chrysalis splits, and gives exit to the perfect winged insect or "imago."

The class *Insecta* is divided into twelve orders, of which only the more important ones require to be noticed here. The wingless or "Apterous" Insects comprise three orders, represented respectively by the disgusting parasites known as Lice, the nearly allied Bird-lice, and the common "Spring-tails," which may be found anywhere under stones or in any damp and dark situation. None of these three orders are of any great importance or interest.

The first order of the Winged Insects is that of the *Hemiptera* (Gr. *hemi*, half; *pteron*, wing), so called because some of its members have the front pair of wings hardened at their bases by horny matter; in others, however, all the wings are simply membranous (fig. 52), and in almost all the two proper pairs of wings are present. The mouth in all the Hemiptera is adapted for suction, and they live upon the juices of plants or animals. As examples of the order may be taken the Field-bug (*Pentatoma*),

the Boat-fly (*Notonecta*), the Cochineal insects (*Coccus*), and the Plant-lice (*Aphis*, fig. 52). The Cochineal insects are of con-

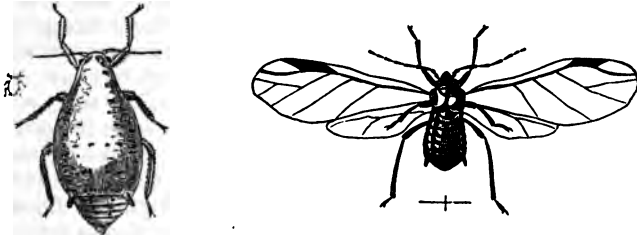


Fig. 52.—Hemiptera. Bean Aphis (*Aphis fabae*), winged male and wingless female.

siderable commercial importance, as the dried and powdered bodies of the female constitute the substance known as Cochineal, from which is obtained the brilliant pigment carmine. The male insect is winged, and is smaller than the female, which is destitute of wings. They live upon different species of Cactus (*Opuntia*), and are mainly imported from Mexico, Algeria, and the Canary Islands.

Numerous species of *Aphides* or Plant-lice are known, and they are amongst the greatest pests of the gardener and farmer, as they are extraordinarily prolific, and live upon the juices of plants. One of the most curious points about the Plant-lice is, that they secrete a sweet sticky fluid, which is expelled from the body by two little tubular filaments placed near the end of the abdomen. Ants are excessively fond of this fluid, and hunt after the *Aphides* in all directions in order to obtain it; and it is a well-established fact that the Plant-lice are actually pleased with this, and voluntarily yield up the coveted fluid to the importunity of the ants.

The next order of Insects is that of the *Orthoptera* (Gr.

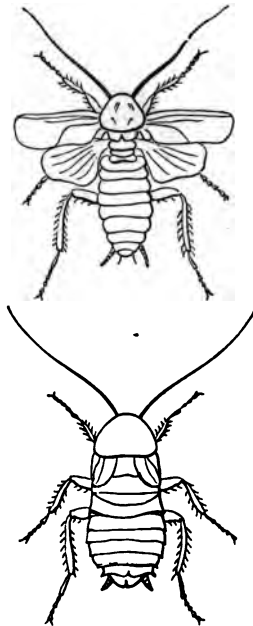


Fig. 53.—Orthoptera. The common Cockroach (*Blatta orientalis*), male and female.

orthos, straight; *pteron*, wing), in which all the four wings are present (fig. 53); but the front wings are generally smaller than the hinder wings, and are of a different texture. The hinder wings are membranous, and are folded lengthways like a fan; the front wings are leathery, and constitute cases for the posterior wings. This order includes the Crickets (*Achetina*), the Grasshoppers (*Gryllina*), the Locusts (*Locustina*), the Cockroaches (*Blattina*, fig. 53), and others. The most important of the *Orthoptera*, from a human point of view, are the Locusts, the ravages of which in hot countries must be familiar to every one. The most destructive species is the Migratory Locust (*Acrydium migratorium*, fig. 54), which is very abundant in Africa, India, and throughout the whole of the East. Owing to the rapidity with which they devour everything that they can possibly eat, and owing to their enormous numbers, the Locusts

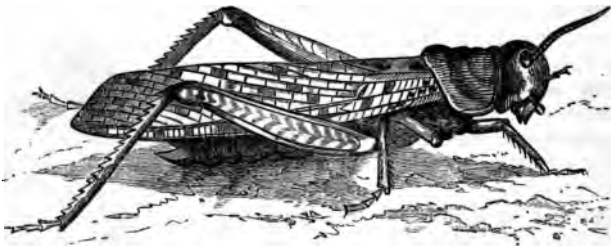


Fig. 54.—The Migratory Locust (*Acrydium migratorium*).

are compelled to be constantly on the move, looking for “fresh fields and pastures new,” otherwise they would starve. It is from these migrations in vast bodies in search of food that the Migratory Locust takes its name. When one of these destructive hosts visits a district, they only need a few hours to convert the most fertile country into a howling wilderness. In an incredibly short space of time every green thing on their line of march is destroyed—every leaf is stripped from every tree, every blade of grass and corn is eaten down, and it is not until the ground is utterly bare that the locusts take wing and seek out some fresh region to devastate.

The next order of Insects is that of the *Neuroptera* (Gr. *neuron*, a nerve; *pteron*, a wing), in which all the four wings are generally present, and are always membranous, being traversed by numerous delicate nervures, which interlace so as to form a delicate net-work (fig. 55). The mouth is adapted for

mastication—that is to say, for chewing hard substances. As examples of the order may be taken the Dragon-flies (*Libellulidæ*), the Caddis - flies (*Phryganeidæ*), the May-flies (*Epheméridæ*), the Aphision (fig. 55), and the White Ants or Termites.

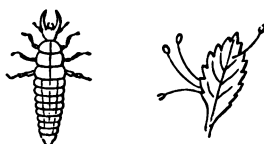
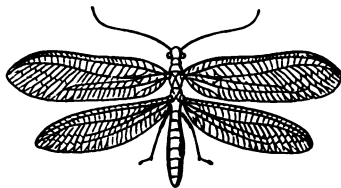


Fig. 55.—Neuroptera. Aphis-lion imago, larva, and eggs.

The Termites (fig. 56) are social insects, living in organised communities, and exhibiting many curious phenomena. Some are found in the warmer parts of Europe, but they are mostly inhabitants of hot countries, such as Africa or South America, where they cause great damage by destroying woodwork of all descriptions. The Termites build mounds of different shapes and sizes, sometimes several feet in height, and mostly composed of earth worked up by the saliva of the insects into a material as hard as stone. Each colony of Termites con-

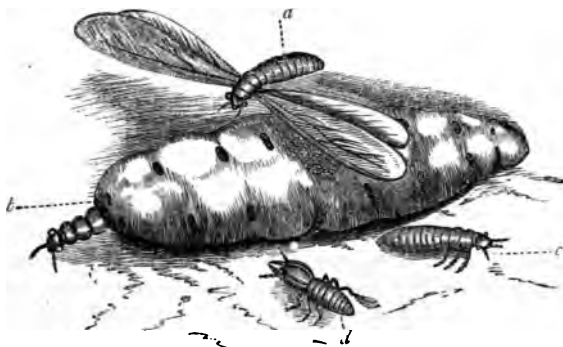


Fig. 56.—Termites (*Termes bellicosus*); *a* King, before the wings are cast off; *b* Queen, with the abdomen distended with eggs; *c* Worker; *d* Soldier.

sists of a king and queen and an enormous number of “neuters,” or individuals of no fully-developed sex. The king (fig. 56, *a*) and the queen (*b*) both originally possessed wings, but they lose

these as soon as they found a colony. They are both much larger than the neuters, the queen immensely so, owing to her being distended with eggs, and they are kept closely guarded in a chamber in the centre of the nest. The "neuters" are really undeveloped females, and are divided into two sets or "castes," both destitute of wings, and known respectively as the "workers" and the "soldiers." The "workers" perform all the ordinary domestic duties of the colony—such as procuring food, nursing the young, and constructing the nest. The "soldiers" have comparatively enormous jaws, and it is their duty to defend the nest against all enemies.

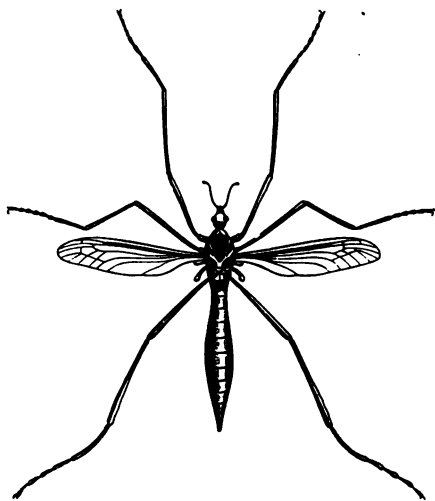


Fig. 57.—Diptera. Crane-fly (*Tipula oleracea*).

Passing over the unimportant order of the *Aphaniptera*, including only the Fleas, we come next to the order *Diptera* (Gr. *dis*, twice; *pteron*, wing). In this order only the front pair of wings is present (fig. 57), and the posterior wings are rudimentary, and are represented by two clubbed filaments called "balancers." The mouth is adapted for suction. As examples of the Dipterous insects may be taken the House-flies and Flesh-flies (*Musca*), the Gnats (*Culex*), the Forest-flies (*Hippobosca*), and the Gad-flies (*Tabanidæ*).

More attractive in every respect than any of the preceding is

the great order *Lepidoptera* (Gr. *lepis*, a scale; *pteron*, a wing), comprising the Butterflies and Moths. The name of the order is derived from the fact that the wings—all four of which are usually present—are generally covered with modified hairs or scales, to which the wings owe their beautiful colours. The mouth is purely suctorial in the adult, and is provided with a spiral trunk fitted for drinking up the juices of flowers. The mouth of the “larva,” however, is adapted for masticating or chewing hard substances, such as the leaves of trees. The larvæ (fig. 58, *a*) are known as “caterpillars,” and are completely worm-like; whilst the pupa is always quiescent, and

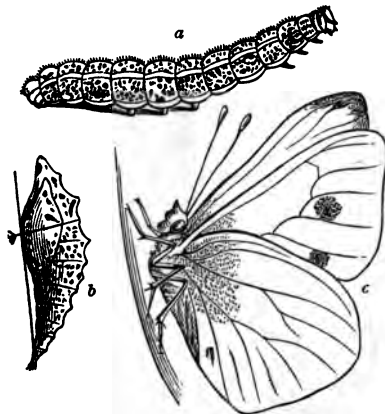


Fig. 58.—Lepidoptera. Large White Cabbage Butterfly (*Pontia brassica*).
a Larva or caterpillar; *b* Pupa or chrysalis; *c* Imago or perfect insect.

is known as the “chrysalis.” The *Lepidoptera* are roughly divided into the two great groups of the Butterflies or Diurnal *Lepidoptera*, which are active in the daytime, and the Moths or Nocturnal *Lepidoptera*, which come out in the twilight or at night. Some of the Moths, however, are active in broad daylight and in the brightest sunshine.

Apart from the destruction committed by the caterpillars of some of the *Lepidoptera*, the only members of the order which are of importance to man are the various species of *Bombyx*, from which *silk* is derived. Several species are cultivated for this purpose, but by far the most valuable is the common Silkworm (*Bombyx mori*), which owes its name to the fact that the caterpillar feeds upon the leaves of the common mulberry (*Mor-*

rus nigra). It is hardly necessary to say that raw silk is derived from the "cocoon" or silken case in which the caterpillar envelops itself before becoming a chrysalis. Most of the raw silk imported into Britain is derived from France, Italy, China, and the East Indies.

The next order of Insects is the large and important one of the *Hymenoptera* (Gr. *humen*, a membrane; *pteron*, a wing), characterised by having four wings, which are all membranous in texture and have few nervures (fig. 59). The mouth is always furnished with biting jaws, but is often adapted for suction as well. The abdomen of the females is generally furnished with an instrument connected with the process of laying

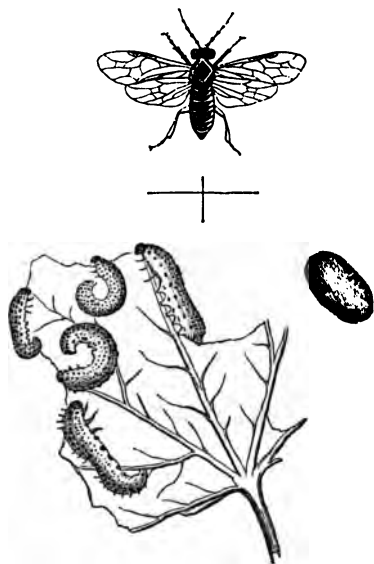


Fig. 59.—Hymenoptera. Gooseberry Saw-fly (*Tenthredo grossulariæ*), larva, pupa, and imago.

eggs ("ovipositor"), and this often is modified to form a "sting." As examples of the order may be taken the Bees (*Apidæ*), the Wasps (*Vespidæ*), the Ants (*Formicidæ*), and the Saw-flies (*Tenthredinidæ*, fig. 59).

The Bees and Wasps are well known as forming social communities, though solitary members of both are not unknown.

In both groups these organised communities consist of a vast number of undeveloped females or "neuters"—the so-called "workers"—presided over by a fertile female or "queen." The males are only produced at certain seasons, and they constitute the so-called "drones" of a hive of Bees. The workers discharge all the ordinary duties necessary for the preservation of the colony, such as procuring food, building the nest, and feeding the young. As there is only one set or "caste" of neuters, the duty of defending the nest falls to the lot of all the workers, and is not delegated to a special class of soldiers. The queen is the founder of the colony, and her sole function is to lay eggs. The drones, or males, do no work, and they either die or are killed by the workers so soon as the female is fertilised.

The Ants (fig. 60) likewise form communities, consisting of males, females, and neuters. The males and females, like those of the very different "White Ants" or Termites, are winged (fig. 60, *a*), and are produced in great numbers at particular times of the year. They then quit the nest and pair, after which the fecundated females lose their wings and form fresh societies. The neuters (fig. 60, *b*) are sometimes all of one kind, but they are sometimes divided into two or even three distinct classes or "castes." The Ants exhibit many most

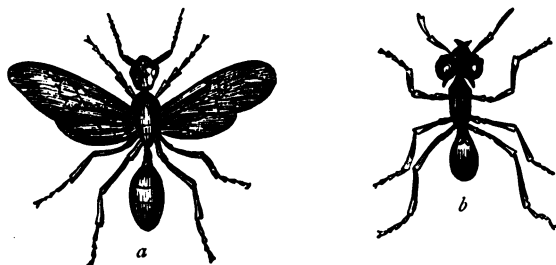


Fig. 60.—The Red Ant (*Myrmica rufa*). *a* Winged male; *b* Wingless neuter, magnified.

extraordinary and interesting instincts and habits, of which their custom of milking the little Plant-lice (*Aphides*) has been already mentioned. Another very singular habit of some Ants may be just alluded to—their habit, namely, of capturing the pupæ of other species of Ants and bringing them up as slaves. The relations, however, between the masters and slaves vary a

good deal in different cases. In the case, for instance, of the Russet Ant (*Formica rufescens*), the masters are so entirely dependent upon their slaves, that they cannot even feed themselves without the help of the latter, and the only work which they perform unassisted is the capturing of fresh slaves. In the Blood-red Ant (*Formica sanguinea*), on the other hand, the slaves are much fewer in number, and the masters are much less dependent upon their good offices. In all cases, the slaves exhibit the greatest devotion to their masters, and are invariably taken the greatest care of by their captors.

Passing over the small group of the *Strepsiptera*, comprising only some small parasites upon Bees and allied insects, we come to the last division of Insects, the Beetles or *Coleoptera* (Gr. *koleos*, a sheath; and *pteron*, wing). The leading peculiarity of the Beetles is that the front wings are hardened



Fig. 61.—Coleoptera. The common Cockchafer (*Melolontha vulgaris*).

by the deposition in them of horny matter, so as to form protective cases or sheaths for the hinder wings (fig. 61). The anterior wings are, therefore, useless as organs of flight, and it is only the posterior membranous wings which are employed in flight. The mouth in all the Beetles is furnished with chewing and biting jaws, and is adapted for dividing solid substances.

The Beetles are, as a general rule, remarkable for their hard polished integument, their glittering, often metallic, colours, and their voracious habits. Many of them do enormous injury to many cultivated plants, either in their larval condition or as perfect insects, or sometimes in both stages of their life. Of the enormous number of known Beetles, the only one which can be said to be of any decided use to man is the so-called "Blister Beetle" or "Spanish Fly" (*Cantharis vesi-*

catoria). This handsome insect is a native of southern Europe, especially of Italy, Spain, and France, and lives upon the leaves of the ash, lilac, elder, and poplar. It is largely collected and exported for medicinal purposes, as it yields one of the most generally used and efficient of blisters.

TABULAR VIEW OF THE DIVISIONS OF THE ANNULOSA.

DIVISION A. ANARTHROPODA.—Locomotive appendages not distinctly jointed or articulated to the body.

CLASS I. GEPHYREA.—*Ex.* Spoon-worms.

CLASS II. ANNELIDA.—*Ex.* Leeches (*Hirudinidae*), Earth-worms (*Oligocheta*), Tube-worms (*Tubicola*), Sand-worms and Sea-worms (*Errantia*).

CLASS III. CHÆTOGNATHA.—*Ex.* Sagitta.

DIVISION B. ARTHROPODA.—Locomotive appendages jointed to the body.

CLASS I.—CRUSTACEA.—*Ex.* Lobsters, Hermit-crabs, and Crabs (*Decapoda*), Wood-lice (*Isopoda*), King-crabs (*Xiphosura*), Barnacles and Acorn-shells (*Cirripedia*).

CLASS II. ARACHNIDA.—*Ex.* Sea-spiders (*Podosomata*), Mites and Ticks (*Acarina*), Scorpions (*Pedipalpi*), Spiders (*Araneida*).

CLASS III. MYRIAPODA.—*Ex.* Centipedes and Millipedes.

CLASS IV. INSECTA.—*Ex.* Lice (*Anoplura*), Bird-lice (*Mallophaga*), Spring-tails (*Thysanura*), Plant-lice (*Hemiptera*), Cockroaches and Grasshoppers (*Orthoptera*), Dragon-flies and May-flies (*Neuroptera*), Fleas (*Aphaniptera*), House-flies (*Diptera*), Butterflies and Moths (*Lepidoptera*), Bees, Wasps, and Ants (*Hymenoptera*), Beetles (*Coleoptera*).

SUB-KINGDOM V. MOLLUSCA.

CHAPTER XIII.

THE *Mollusca* (Lat. *mollis*, soft) owe their scientific name to the fact that they have usually a soft body, but this is usually protected by a hard external skeleton or "shell," and hence the popular name of "Shell-fish" applied to the animals of this sub-kingdom. All the *Mollusca* are furnished with a distinct alimentary canal, which is always completely shut off from the general cavity of the body (fig. 62, *a*). Sometimes there is no distinct organ of the circulation, but when there is, it is placed on the dorsal aspect of the body. The nervous system of the *Mol-*

lusca is wholly different in its arrangement from that of the *Annulose* animals, and in the lower forms it consists of only a single ganglionic mass, giving off filaments in various directions. In the higher *Mollusca* the nervous system (fig. 62) consists of three principal ganglia, distributed in a characteristically scattered

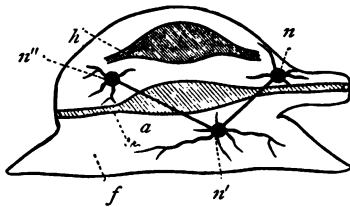


Fig. 62.—Diagram of a Mollusc: *a* Alimentary canal; *h* Heart; *f* Foot; *n*, *n'*, *n''*, the three great ganglia of the nervous system.

manner, and united to one another by cords. The most important of these ganglia is the "pedal" ganglion (fig. 62, *n'*), so called because it supplies nerves to the great locomotive organ of most Molluscs, the "foot." There may be no distinct breathing organs, but as a rule these are present, either in the form of gills or "branchiæ," or as air-chambers, adapted for breathing air directly. All the higher Molluscs are simple animals, and perpetuate their kind solely by means of ova; but many of the lower forms have the power of throwing out buds and of producing colonies, much as we have formerly seen in the Hydroid zoophytes.

In accordance with the nature of the nervous and circulatory systems, the *Mollusca* are divided into two great sections, known respectively as the *Molluscoida* and *Mollusca Proper*. In the *Molluscoida* there is either no circulatory organ or an imperfect heart, and the nervous system consists of a single ganglion or of a principal pair of ganglia. In this division are included the Sea-mosses and Sea-mats (*Polyzoa*), the Sea-squirts (*Tunicata*), and the Lamp-shells and their allies (*Brachiopoda*). In the *Mollusca Proper*, on the other hand, the nervous system consists of three principal pairs of ganglia, and there is a well-developed heart, consisting of at least two chambers. Under this head are included the Bivalve shell-fish, such as Oysters, Cockles, and the like (*Lamellibranchiata*), the Univalve shell-fish, as Whelks, Periwinkles, Slugs, and the like (*Gasteropoda*), certain minute free-swimming Molluscs (*Pteropoda*), and the Cuttle-fishes and Nautilus (*Cephalopoda*). All these groups require to be briefly considered.

CHAPTER XIV.

MOLLUSCOIDA.

CLASS I. POLYZOA.—The *Polyzoa* (Gr. *polus*, many; *zoa*, animals) are the lowest of the *Mollusca*, and would not be generally recognised as Shell-fish at all. They are popularly known as "Sea-mosses" and "Sea-mats," and are almost universally regarded as sea-weeds by visitors at the sea-side. They are

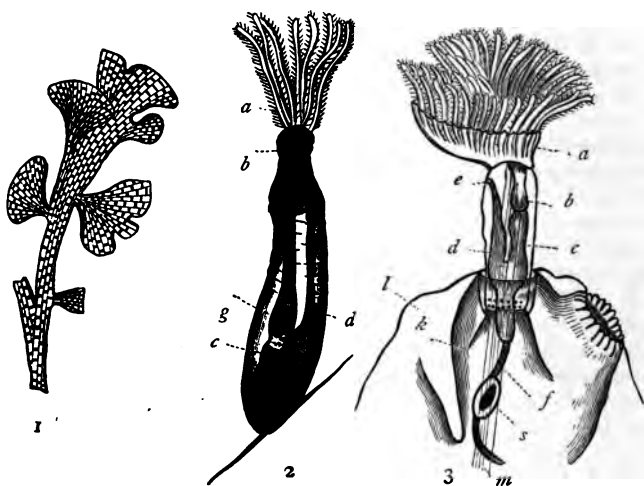


Fig. 63.—Polyzoa: 1. Fragment of one of the Sea-mats (*Flustra*), natural size; 2. A single polypide of *Valerka*, magnified, showing the circular crown of tentacles; 3. A polypide of *Lophopus*, magnified, showing the horse-shoe-shaped crown of tentacles.

invariably compound—that is to say, they form associated growths or colonies, each consisting of a number of distinct but separate "zoöids," produced by budding from a single primitive organism. The zoöids are called "polypides," the

term "polypite" being only used in connection with the *Hydrozoa*, and the term "polype" being similarly restricted to the *Actinozoa*. The colonies of the *Polyzoa* are very generally protected by a horny or calcareous covering, and they are in many cases so like the Hydroid Zoophytes as to have been long described as such. The zooids or polypides, however, of the *Polyzoa*, are much more highly organised than those of the *Hydrozoa*, since they possess a nervous system, a distinct alimentary canal entirely shut off from the general cavity of the body, and distinct internal reproductive organs.

With a single exception, the colonies of the *Polyzoa* are all rooted to some solid object, and, as an example, we may take the Sea-mat (*Flustra*, fig. 63, 1). If such a colony be examined, it is found to consist of an assemblage of little cells or chambers, composed of a horny or calcareous matter, and not communicating one with the other. Each cell contains a minute polypide, the essential structure of which is much higher than that of the *Hydrozoa*. Each polypide possesses a distinct alimentary canal, with a mouth and vent placed at the mouth or aperture of the cell. The mouth is surrounded by a beautiful crown of delicate ciliated tentacles, which are sometimes arranged in a circle (fig. 63, 2), sometimes in a horse-shoe or crescent (fig. 63, 3). These tentacles serve both to procure food, and as breathing-organs, for there are no gills. On one side of the gullet is placed a single nervous ganglion, and the cell likewise contains the reproductive organs proper to both sexes; but there is no heart. The whole cavity of the cell, however, is filled with a fluid containing solid particles, and corresponding to the blood.

The *Polyzoa* are most commonly and most abundantly found in the sea, but many very beautiful forms are natives of fresh water, and may be found in the ponds, lakes, and streams of our own country.

CLASS II. TUNICATA.—This class includes a class of animals not at all familiarly known, and mostly of small size. They are often called *Ascidians* (Gr. *askos*, a wine-skin), from the resemblance which many of them exhibit in shape to a two-necked jar or bottle (fig. 64, 2). Their scientific name of *Tunicata* is derived from the fact that the body is enclosed in a leathery integument, which takes the place of the shell of the higher Molluscs. It is remarkable for the fact that it contains a substance which appears to be nearly if not quite identical with "cellulose," the starchy body which forms wood and the woody

parts of plants. The two orifices in the outer leathery case or "test" of the *Tunicata* lead into the interior of the animal, and

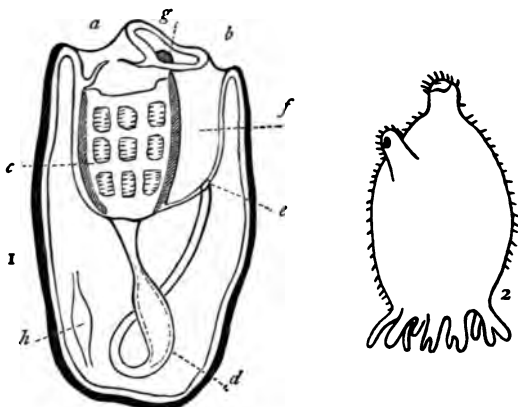


Fig. 64.—Tunicata. 1. Diagram of a Tunicary (after Allman): *a* Mouth; *b* The second opening of the "test"; *c* Respiratory sac, with its rows of ciliated apertures; *e* Anus; *g* Nervous ganglion. 2. A simple Ascidian (*Cynthia*).

are used for the admission and expulsion of sea-water; and by their means the animal both breathes and obtains food. The opening by which water is admitted is generally regarded as the mouth (fig. 64, 1 *a*), and it leads into a great chamber called the "respiratory sac" (*c*). This sac has its walls perforated like a sieve with numerous ciliated apertures, which lead into a second chamber (*f*) situated at the other extremity of the alimentary canal, and communicating with the outer world by the second opening in the test (*b*). A constant current of water sets in at the mouth, through the respiratory sac, and out again at the second opening of the test. In this way food is obtained, and the animal respire, for the walls of the respiratory sac are richly furnished with blood-vessels. From the bottom of the respiratory sac proceeds the alimentary canal (*d*), to terminate by a distinct vent at the bottom of the chamber into which the second aperture of the test opens. On one side of the mouth is a single nervous ganglion. There is also a distinct heart, but this is a simple tube, open at both ends, and driving the blood periodically first in one direction and then in the opposite.

The Tunicaries owe their name of "Sea-Squirts" to the power which they possess of forcibly ejecting a stream of water from the orifices of the test when touched or otherwise irritated.

This power they owe to the presence of a muscular tunic lining the leathery outer case or "test." All the *Tunicata* are marine, and the smaller ones are commonly found sticking to stones or shells at low water or in shallow seas. Some of the tropical forms are found floating in the open ocean far from land, and some are very beautifully phosphorescent at night. Many of the *Tunicata* are simple organisms, but others have the power of producing associated growths or colonies by a process of budding.

CLASS III. BRACHIOPODA.—This class includes the so-called Lamp-shells and their allies, and is much more largely represented by fossil forms than by living species. The Lamp-shells are so called because of the resemblance in shape of one valve of the shell (in some cases) to an antique lamp. The name of *Brachiopoda*, however, is derived from the fact that the mouth is furnished with two long spirally-coiled "arms," which carry numerous minute lateral processes or "cirri" (Gr. *brachion*, arm; *pous*, foot). In many instances these arms are supported by a kind of shelly framework, and in all cases they serve to obtain food for the animal. The internal anatomy of the *Brachiopoda* presents many points of relationship to that of the *Polyzoa* and *Tunicata*, especially the former; but the Brachiopods are distinguished by the above-mentioned "arms," and by the fact that the body is always enclosed in a calcareous shell. This shell is always *bivalve*—that is to say, it consists of two pieces or "valves," which are placed respectively on the front and back of the animal. The ventral valve is usually the largest, and generally has its apex or "beak" pierced by an aperture for the transmission of a muscular stalk, by which the shell is moored to some solid object. In some cases, however, as in *Lingula* (fig. 65), the stalk of attachment simply passes between the valves. All the *Brachiopoda* are natives of the sea; and though very few species are known to exist at the present day, they have a very wide distribution over the world.



Fig. 65. — Brachiopoda. *Lingula*, showing the muscular stalk by which the shell is attached.

CHAPTER XV.

MOLLUSCA PROPER.

THE division of the *Mollusca Proper* includes the following four classes :—

- | | |
|-------------------------------|--|
| 1. <i>Lamellibranchiata</i> , | without a distinct head. |
| 2. <i>Gasteropoda</i> , | } with a distinct head and a masticatory apparatus or "odontophore." |
| 3. <i>Pteropoda</i> , | |
| 4. <i>Cephalopoda</i> , | |

CLASS I. LAMELLIBRANCHIATA.—These are well known as *Bivalve Shell-fish*, such as Oysters, Mussels, Scallops, &c.; and they are all either marine or inhabitants of fresh water. They are distinguished from the other shell-fish by having no distinct head, and by having the body more or less completely protected by a "double" or bivalve shell, composed of two pieces or "valves," which cover respectively the left and right sides of the animal. The body is more or less completely enclosed in an expansion of the integument which constitutes what is called the "mantle," and it is by the mantle that the shell is secreted. The mantle, therefore, is like the shell, composed of two halves; but the halves of the mantle are often united to one another to a great extent, and the mantle-lobes are often prolonged at one point into two long respiratory tubes by which water is conducted to the breathing-organs (fig. 66, *ss*). However completely the halves or "lobes" of the mantle may be united to one another, there is always an opening for the protrusion of the "foot," when this is present, besides the opening by which water is admitted to the gills. The "foot" is sometimes absent, or very small, but it is usually a tongue-like or hatchet-shaped muscular organ (fig. 66, *f*), which may perform very different functions. Usually it enables the animal to make short leaps, or to bury itself in the sand; but in other cases (as in the common Mussel) it is connected with a gland which

secretes the tuft of silky threads by which these shells are temporarily or permanently moored to solid objects.

As the shell of the bivalves consists of two pieces, special means are necessary for its opening and closure. The closure of the shell is effected by means of one or two muscular bands (fig. 66, *a a*), by which the valves are pulled together. The shell is opened simply by relaxing these muscles, when the valves spring apart in consequence of the elastic force of a band of horny fibres situated between the points or "beaks" of the valves. In most cases, also, besides the "ligament" just mentioned, the valves are united to one another at the beaks by means of interlocking projections or "teeth."

The breathing-organs of the bivalves are in the form of two or four leaf-like gills (fig. 66, *b*), hence their name of *Lamellibranchiata* (Lat. *lamella*, a thin plate; Gr. *brachia*, gill). When the lobes of the mantle are not united to one another, the water is admitted to the gills simply by opening the valves of the shell. When the opposite is the case, the water is admitted by one aperture and let out again by another. Very often, especially in those bivalves which live buried in sand or mud, the margins of these openings are prolonged into longer or shorter tubes, which may be

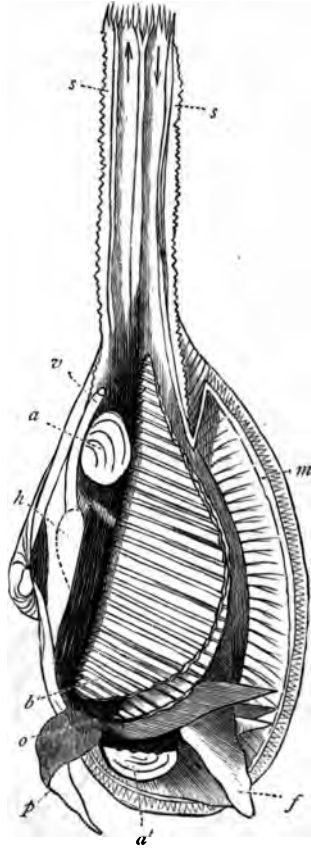


Fig. 66.—Anatomy of a bivalve Mollusc. *Mya arenaria* (after Woodward). The left valve and mantle-lobe and half the respiratory tubes are removed. *s s* Respiratory tubes; *a a* Muscles by which the shell is closed; *b* Gills; *h* Heart; *o* Mouth; *f* Foot; *m* Cut edge of the mantle.

separate or may be united on one side (fig. 66, *s s*). The mouth is furnished with membranous processes, and has no teeth. The particles of food are conveyed to the mouth by the currents of water which are conducted to the gills, and which are driven along by the innumerable vibrating filaments or cilia covering these organs. There is always a distinct heart, of two or three chambers, and the blood is colourless, or nearly so. The nervous system consists of the principal pairs of ganglia proper to the higher Molluscs.

The habits of the *Lamellibranchiata* are very various. Some, such as the Scallops, habitually lie on one side, the lower valve being the deepest. Others are fixed to the bottom of the sea by the substance of one of the valves. Others, such as the Mussel, moor themselves to solid objects by a tuft of silky fibres. Very many live buried in the sand of the sea-shore or the mud of estuaries. Others bore holes in stone or wood, in which they live. Finally, many are permanently free and locomotive.

CLASS II. GASTEROPODA.—The Molluscs of this class—such as Snails, Whelks, Limpets, Slugs, and Sea-lemons—differ from the Bivalves in having a very distinct head, in having a curious apparatus of teeth, and in never having a bivalve shell. From the very common occurrence of a shell composed of a single piece, the *Gasteropoda* are often spoken of in a general way as

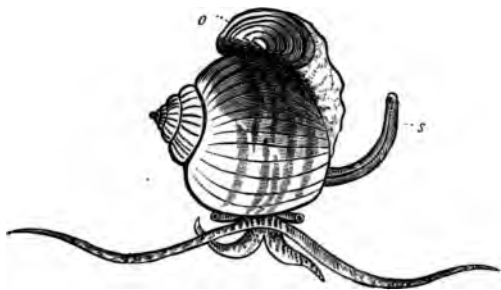


Fig. 67.—*Ampullaria*, one of the Apple shells. *o* Operculum;
s Respiratory tube.

Univalves (fig. 67). Many, however, have only a very small shell completely concealed from view (fig. 71); others have no shell at all; and a few have a shell composed of several pieces ("multivalve"). Most of the *Gasteropoda* are further distinguished

by the great development of the foot, which forms a broad flattened disc, on which they creep about, as may be seen in the common Slugs. From this circumstance the name *Gastropoda* is derived (Gr. *gaster*, belly; *pous*, foot). Some, however, have the foot much modified, and adapted for swimming (fig. 70). In many, also, the hinder part of the foot carries a horny or shelly plate, called the "operculum" (fig. 67, *o*), which serves to close the shell when the animal is withdrawn within it.

As before said, the head of the Gastropods (fig. 67) is very well marked, and carries two feelers and two eyes, which are often placed on stalks. The mouth is furnished with a curious apparatus of teeth, constituting what is known as the "tongue" or "odontophore" (fig. 68). It consists of a number of minute flinty teeth carried upon a sort of strap, which works backwards and forwards on a cushion, and acts like a chain-saw.

In most of the ordinary Gastropods the breathing-organs are in the form of distinct gills or branchiæ, placed in a more or less complete chamber, formed by a folding of the mantle. In many of these the water gains access to the gills by a respiratory tube, which is protected in a notch or tubular prolongation of the mouth of the shell, as may be seen in the common Whelk. In other cases, however, there is no such respiratory tube, and the mouth of the shell is therefore not notched, but is simply rounded, as may be seen in the Periwinkle. It has also been observed that those Gastropods which have the mouth of the shell notched are mostly animal feeders; whilst those in which the mouth of the shell is simply rounded, live upon vegetable matters.

As far as the ordinary water-breathing Gastropods are concerned, it only remains to add a few words about the shell. The shell may be *multivalve*, or composed of several pieces, but in the great majority of cases it is *univalve*, or composed of but a single piece. It is essentially a hollow cone, with the apex placed a little on one side. In the simplest forms, as in the Limpets, this conical form is permanently retained. In most cases, however, the cone is greatly elongated, and forms a tube which is variously coiled up. In the most typical forms the coils or "whorls" of the shell are wound obliquely round a central pillar, increasing gradually in size to the mouth (fig. 67).



Fig. 68.—Portion of the tongue or odontophore of the common Whelk (after Woodward).

In some cases, however, the whorls form a flat spiral, and in others the last whorl completely conceals those which preceded it.

Three groups of the *Gasteropoda* still require a brief consideration. The first of these is represented by the Sea-lemons (fig.



Fig. 69.—*Doris Johnstoni*, one of the Sea-lemons.

69) and their allies, specimens of which may be at any time found creeping about on sea-weeds or attached to the under surface of stones at low water. When fully grown, these slug-like Molluscs are wholly destitute of a shell, but they have a small shell when young. When they possess any

distinct respiratory organs, these are in the form of gills, which are not protected in a chamber of the mantle, but are placed without any defence on the back or sides of the body. Hence the scientific name of *Nudibranchiata* (Lat. *nudus*, naked; Gr. *bragchia*, gill) applied to this group.

The second group is that of the *Heteropoda* (Gr. *heteros*, diverse; *pous*, foot), comprising a number of curious forms which are found swimming about at the surface of the open ocean, instead of creeping about at the bottom of the sea. In order to adapt them for this mode of life, the foot is so modified as to form a compressed fin, instead of being a creeping disc. *Carinaria* (fig. 70) may be taken as a good example of the group.



Fig. 70.—*Carinaria* (after Woodward). *p* Proboscis and mouth; *t* Tentacles; *g* Gills; *s* Shell; *f* Foot.

It has only a very small limpet-shaped shell protecting the gills; but some of the Heteropods have a large shell, capable of protecting the entire body of the animal. *Carinaria* is found, swimming back downwards, in the Mediterranean and other

warm seas, and is so transparent that the course of the intestine can be seen along its whole length.

The last group of the class is that of the "air-breathing" Gasteropods, so well known as Land-snails, Pond-snails, and Slugs (fig. 71). All the members of this group are formed to breathe air directly, instead of through the medium of water,

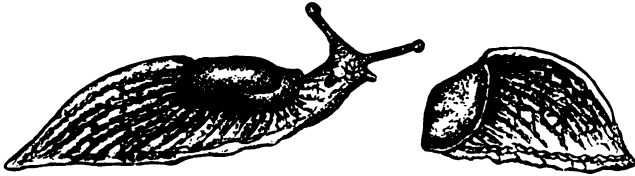


Fig. 71.—*Limax Sowerbyi*, one of the Slugs (after Woodward).

and they therefore never possess gills or branchiæ. In place of these, they have a pulmonary chamber or lung, formed by a folding of the mantle, and having air admitted to it by a round hole on the right side of the neck, which can be opened or shut at will. Though thus adapted for breathing air directly, many of the members of this group can only live in damp and moist places, whilst others habitually live in fresh water. Our common Pond-snails are good examples of these last. The condition of the shell varies very much. Some, such as the common Land-snails, have a well-developed shell within which the animals can completely withdraw themselves for protection. Others, such as the common Slugs (fig. 71), have a rudimentary shell

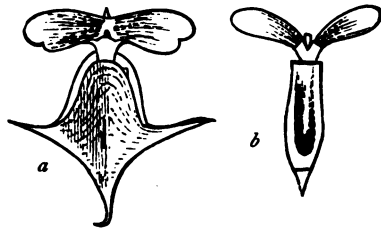


Fig. 72.—Pteropods (after Woodward).

which is completely concealed within the mantle. Others are entirely destitute of a shell. They all agree with the typical Gasteropods in creeping about upon a broad flattened foot.

CLASS III. PTEROPODA.—The Molluscs included in this class

are all very minute in point of size, and they are all "oceanic"—that is to say, they are found swimming near the surface of the open ocean, far from land, and often in enormous numbers. They are distinguished by having two wing-like fins (fig. 72) attached to the sides of the head, and formed by a modification of a portion of the foot. As a rule, the body is protected by a delicate symmetrical glassy shell, but some have the body completely naked. The Pteropods are found in all seas, from the tropics to within the arctic circle; and they sometimes occur in such numbers as to discolour the water of the ocean for many miles. They constitute one of the chief articles of food of the whale, and are in turn themselves carnivorous.

CLASS IV. CEPHALOPODA.—The last and highest class of the *Mollusca* is that of the *Cephalopoda*, comprising the Cuttle-fishes and their allies, together with the Pearly Nautilus. The name of *Cephalopoda* or "head-footed" Molluscs (Gr. *kephalé*, head;

pous, foot) is derived from the fact that the head is surrounded by a number of processes or "arms" (fig. 73), which enable the animal to creep about head downwards at the bottom of the sea. The Cuttle-fishes can also swim, either by means of fins or by forcibly emitting jets of water from the mantle-cavity, the reaction driving the animal in the opposite direction. Most of the living Cephalopods possess only an internal skeleton, but the Argonaut (Paper Nautilus) and the Pearly Nautilus have an external shell, though the nature of this is very different in the two forms.

In their structure the Cephalopods are the most highly organised of all the Molluscs. The head (fig. 73) is very distinct, carrying two large globular eyes, and having the mouth in its centre. The mouth is surrounded



Fig. 73.—*Sepioides Atlantica*, one of the Cuttle-fishes (after Woodward).

by eight, ten, or more muscular processes or "arms," which

are usually furnished with numerous suckers. By the help of these the animal can seize its prey or can moor itself to some solid object with the utmost tenacity. Generally there are only eight arms; sometimes there are ten, two of these being longer than the others, and carrying suckers only towards their ends (fig. 73). In the Paper Nautilus two of the arms are webbed, and secrete a shell (fig. 74). Lastly, in the Pearly Nautilus (fig. 75) the arms are numerous, more than ten in number, and destitute of suckers.

The mouth conducts into a chamber containing two horny jaws, very like the beak of a parrot, together with a "tongue" or "odontophore." The intestine terminates at the base of a muscular tube which is placed on the under surface of the head, and is known as the "funnel." The funnel communicates with the cavity of the mantle on one hand and the outer water on the other. By the contractions of the muscular mantle, the water contained in the mantle-cavity is driven in jets through the funnel, and the animal is driven in the opposite direction. Through the funnel, also, is emitted the secretion of the "ink-bag," an organ found in all the Cuttle-fishes. It secretes a peculiar inky fluid which the animal can discharge into the water at will, and under cover of which it makes its escape when menaced or pursued. The breathing-organs are in the form of two or four plume-like gills or branchiæ contained within the mantle-cavity. In almost all the living Cephalopods there are only two gills, and these constitute the section *Dibranchiata* (Gr. *dis*, twice; *bragchia*, gill). In the Pearly Nautilus alone of all living Cephalopods there are four gills, and hence, with its fossil relatives, it forms the order *Tetrabranchiata* (Gr. *tetra*, four; *bragchia*, gill). The nervous system of the *Cephalopoda* is highly developed, and the ganglia which correspond to the brain are protected by a cartilage which foreshadows the skull of the Vertebrate animals. The sexes are always distinct, and the process of reproduction is attended with some very singular phenomena, which cannot be noticed here.

The section of the *Dibranchiate Cephalopods*, with two gills, comprises the Cuttle-fishes and their allies, together with the Paper Nautilus. They almost never have an external shell; they have no more than eight or ten arms, furnished with suckers; and they have an ink-bag. When there are ten arms (as in fig. 73), two of these are longer than the others, and only carry suckers towards their extremities, which are enlarged and club-shaped. The Cuttle-fishes and their allies the Calamaries are very widely distributed, some frequenting rocky shores,

whilst others are found in the open ocean. They are all active and voracious animals, and they sometimes attain a perfectly enormous size. They never have any external shell, but they have a more or less extensively developed internal skeleton.

The only Dibranchiate Cephalopod which possesses an external shell is the Paper Nautilus or Argonaut (fig. 74), and in this the shell is confined to the female. The male is only about an inch in length, and is exactly like the ordinary Cuttlefishes. The female is considerably larger than the male, and

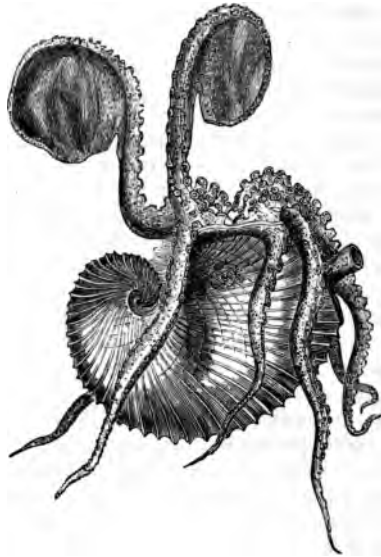


Fig. 74.—*Argonauta argo*, the Paper Nautilus, female. The animal is represented in its shell, but the webbed dorsal arms are separated from the shell, which they secrete, and which they ordinarily embrace.

inhabits a beautiful one-chambered cell, which is secreted by the webbed extremities of two of the arms. The shell is not in any way attached to the body, but the webbed arms are turned backwards, and the animal sits in the shell with the "funnel" turned towards the keel. It swims by the jets of water emitted from the funnel, and crawls upon the sea-bottom, head downwards, carrying its shell upon its back. It is found in the warmer seas of various parts of the world, generally floating at the surface.

The section of the *Tetrabranchiate Cephalopods* comprises those forms which have the body protected by an external many-chambered shell. The arms are more than ten in number, and have no suckers. There are four gills, two on each side of the body; and there is no ink-bag. Very many and beautiful forms of Tetrabranchiate Cephalopods are known as fossils, but the order is represented at the present day by no more than a single living form, the Pearly Nautilus, so well known by its beautiful chambered shell. The shell of the Pearly Nautilus (fig. 75) is coiled into a spiral, and is composed of many chambers walled off from one another by curved shelly partitions, perforated centrally by apertures, which transmit a membranous tube or "siphuncle." The separate chambers of the

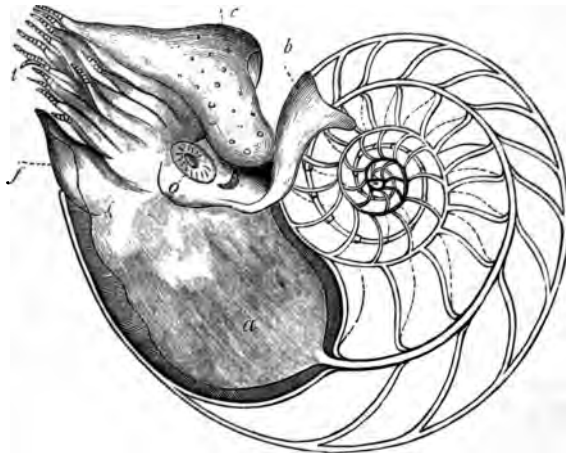


Fig. 75.—The Pearly Nautilus (*Nautilus pompilius*). *a* Mantle; *o* Eye; *t* Tentacles; *f* Funnel.

shell are filled with gas, and appear to act as a kind of float, reducing the specific gravity of the shell to near that of the surrounding water. The animal inhabits only the last and largest chamber of the shell, from which it can protrude the head at will. Though the shell is by no means uncommon, only a single perfect specimen of the animal has hitherto been discovered.

Amongst the more beautiful and familiar of the fossil relatives of the Pearly Nautilus may be mentioned the *Ammonites*, the

shells of which are so abundant in the so-called Secondary rocks of geologists.

TABLE OF THE MAIN DIVISIONS OF THE MOLLUSCA.

DIVISION A. MOLLUSCOIDA.—Nervous system consisting of a single ganglion, or a principal pair of ganglia ; no heart, or only an imperfect one.

CLASS I. *Polynoa*.—*Ex.* Sea-mats (*Flustra*).

CLASS II. *Tunicata*.—*Ex.* Sea-squirts (*Ascidia*).

CLASS III. *Brachiopoda*.—*Ex.* Lamp-shells (*Terebratula*).

DIVISION B. MOLLUSCA PROPER.—Nervous system consisting of three principal pairs of ganglia ; heart well developed, composed of at least two chambers.

CLASS I. *Lamellibranchiata*.—*Ex.* Oyster (*Ostrea*), Mussel (*Mytilus*), Cockle (*Cardium*).

CLASS II. *Gasteropoda*.—*Ex.* Whelks (*Buccinum*), Periwinkles (*Littorina*), Sea-lemons (*Doris*), Land-snails (*Helix*).

CLASS III. *Pteropoda*.—*Ex.* *Cleodora*.

CLASS IV. *Cephalopoda*.

Order *a.* *Dibranchiata*.—*Ex.* Poulpe (*Octopus*), Paper Nautilus (*Argonauta*).

Order *b.* *Tetrabranchiata*.—*Ex.* Pearly Nautilus.

VERTEBRATE ANIMALS.



CHAPTER XVI.

GENERAL CHARACTERS OF THE VERTEBRATA.

As before remarked, the five sub-kingdoms which have now been considered—viz., the *Protozoa*, *Cœlenterata*, *Annuloida*, *Annulosa*, and *Mollusca*—are commonly grouped together under the name of *Invertebrata*, or Invertebrate animals. To complete our survey of the animal kingdom, there remains only to consider the sixth and last sub-kingdom—that of the *Vertebrata*, or Vertebrate animals.

The sub-kingdom *Vertebrata* includes the five great classes of the Fishes, Amphibians, Reptiles, Birds, and Mammals; and the name of the sub-kingdom is derived from the very general, though not universal, presence of the bony stem known as the "vertebral column," spine, or backbone. In its most complete form the vertebral column consists of a number of separate bony segments or "vertebræ," arranged so as to form a bony axis upon which the part of the nervous system called the "spinal cord" is supported. In some cases, however, the vertebral column is only partially bony, and in other cases it remains permanently and completely in the condition of gristle (cartilage). Lastly, in some cases no vertebral column is ever developed, but the spinal cord is supported by a peculiar rod-like structure, consisting of cells enclosed in a fibrous sheath, and termed the "notochord."

Another great peculiarity of Vertebrate animals is shown by making a transverse section of the body, or cutting it in two (fig. 1). If the body of any of the higher Invertebrate animals be cut in two, it is found that the body consists of only a single tube, which encloses all the vital organs, so that the main

masses of the nervous system are not in any way shut off or separated from the alimentary canal. This is not the case, however, with the Vertebrate animals. In them, the body, when cut in two (fig. 1, B), exhibits *two* tubes. One of these contains the alimentary canal and heart, with certain portions of the nervous system, whilst the other contains the main masses of the nervous system—namely, the brain and spinal cord.

The remaining important characters which distinguish the Vertebrate animals as a whole, are the possession of an *internal* skeleton to which the muscles are attached, and the fact that there are *never more than two pairs of limbs*, which are jointed to the body, and are turned away from that side of the body upon which the main masses of the nervous system are placed.

It will be as well, before proceeding further, to give here a very brief account of the general anatomy of one of the higher Vertebrates, such as a Mammal, and we may advantageously commence with the skeleton. The *skeleton* of a Vertebrate animal may be regarded as consisting of the bones which go to form the head and body (trunk) on the one hand, and of those which form the supports for the limbs on the other hand. The bones of the head and trunk may be regarded as essentially composed of a number of bony rings arranged one behind the other. In front these rings are greatly widened out to enclose the brain, and they constitute what is known as the "cranium"

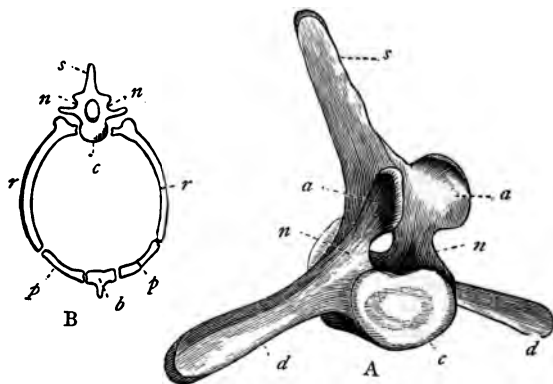


Fig. 76.—A, Vertebra of Whale: *c* Body; *n n* Arches enclosing the spinal cord.
B, Diagram of a vertebra in the region of the chest. (After Owen.)

or skull (fig. 77). Behind the head the rings are much smaller, and they enclose the spinal cord, whence they are collectively

known as the "spinal" or "vertebral column." The rings or segments of the vertebral column are called "vertebræ," and each vertebra (fig. 76) has the following general structure: The central portion of the vertebra is called the "body" (fig. 76, *c*), and gives off two long arches (*n n*), which unite above the body of the bone, and enclose a canal or tube. Both the body and the two arches give off certain projecting pieces or "processes," which are of great importance in the study of anatomy, but which need not be particularised here.

The bodies of the vertebræ are united to one another in such a manner as to give the entire column great flexibility. Further, by the apposition of the canals which are formed by the arches of the vertebræ, a continuous tube is formed, in which the spinal cord is contained secure from any injury which might befall it in the movements of the vertebral column.

As a general rule, the following *regions* (fig. 77) may be

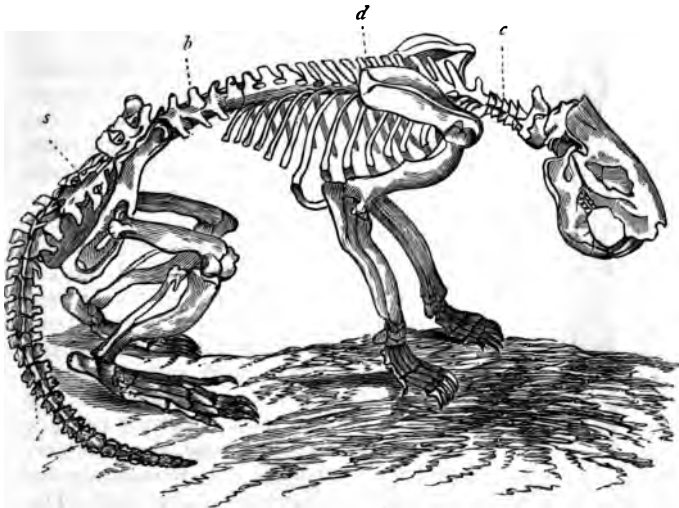


Fig. 77.—Skeleton of the Beaver, showing the regions of the vertebral column. *c* Cervical region, or neck; *d* Dorsal region, or region of the back; *b* Lumbar region, or region of the loins; *s* Sacrum; *t* Caudal region, or region of the tail.

recognised in the vertebral column of the higher Vertebrates:—Firstly, the *cervical region* (Lat. *cervix*, the neck), comprising a variable number of vertebræ which constitute the "neck,"

and which immediately succeed the head. Secondly, the neck is followed by a varying number of vertebræ which constitute the *dorsal region* (*d*), or region of the back, and which usually carry ribs. Thirdly, the vertebræ of the back are followed by certain vertebræ (*l*) which constitute the *lumbar region*, or region of the loins (Lat. *lumbus*, a loin). Fourthly, there usually follows a series of vertebræ, which are immovably united together so as to constitute a single bone (*s*), which is termed the *sacrum* (Lat. *sacer*, sacred; so called from an ancient superstition concerning it). Finally, there comes a variable series of vertebræ (*t*), which are usually freely movable upon one another, and which constitute the *caudal region*, or region of the tail (Lat. *cauda*, tail).

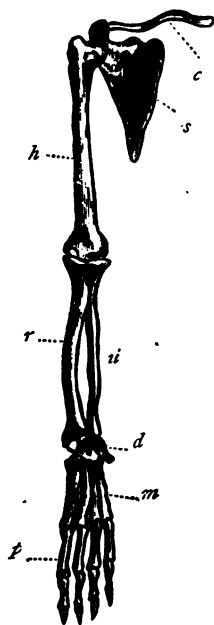


Fig. 78.—Fore limb of Chimpanzee. *c* Collar-bone, or clavicle; *s* Shoulder-blade, or scapula; *h* Humerus; *r* Radius; *u* Ulna; *d* Bones of the wrist, or carpus; *m* Bones of the root of the hand, or metacarpus; *t* Bones of the fingers, or phalanges.

The cavity of the chest in almost all Vertebrates is bounded by a number of slender curved bones, which are attached behind to the dorsal vertebræ, and which are known as the *ribs*. In front the ribs usually unite by cartilages with a bone or chain of bones known as the breast-bone or *sternum*. The sternum, however, is sometimes wanting, and there are sometimes ribs which are not attached to the breast-bone in front.

In examining the *limbs* of the higher Vertebrates, it is at once obvious that the two pairs are constructed upon a similar plan. If we take the highest type of fore limb, as seen in the Mammals (fig. 78), we find it to consist of the following parts: 1. A series of bones connecting the limb to the trunk or body, the two most important being a flattened plate-like bone, the shoulder-blade or *scapula* (*s*), and a rounded slender bone, the collar-bone or *clavicle* (*c*). The former, however, really consists of two distinct bones united together, and the latter is often wanting. 2. The bone which forms the upper arm, and extends from the shoulder to the elbow. This is known as the *humerus* (*h*). 3. The two bones of the forearm, which are known as the *radius* (*r*) and *ulna* (*u*). These

extend from the elbow to the wrist. 4. A number of little bones (*d*) which constitute the wrist itself, and are called the *carpus*. 5. Several cylindrical bones (properly five in number) which constitute the root of the hand, and are termed the *metacarpus* (*m*). 6. The small cylindrical bones of the fingers themselves, known as the *phalanges* (*p*).

Similar parts are found in the hind-limb of a Mammal (fig. 79), but here they have different names. The bones which connect the hind limb to the body are amalgamated together, and they form on each side a single bone termed the *innominate bone* (*i*). This is succeeded by the single long bone which forms the thigh, and is known as the thigh-bone or *femur* (*f*). Below this are the two bones of the shank or leg proper, known as the *tibia* or shin-bone (*t*) and the *fibula* (*s*). These are followed by a number of small bones which constitute the ankle-joint, and are termed the *tarsus* (*r*). This in turn is succeeded by several cylindrical bones (properly five in number) which constitute the root of the foot, and are termed the *metatarsus* (*m*). These are finally succeeded by the bones of the toes or *phalanges* (*p*). By comparing the two illustrations with one another, the general correspondence between the bones of the fore and hind limbs will be at once evident. The student, however, must bear in mind that very often one or both of the two pairs of limbs proper to the Vertebrates may be so modified to suit some particular purpose, that the above-mentioned parts may cease to be recognisable, or may be very difficult to trace.

As to the *digestive system* of Vertebrates (fig. 80), the food is conducted to the stomach by a muscular tube termed the gullet (*g*). In the stomach the food becomes to a great extent digested, by the action upon it of the fluid secreted by this organ. From the stomach the food passes into a long convoluted muscular tube, which is known as the "small intestine" (*sm*). Here it is mixed with the "bile" secreted by the liver, and also with the fluid secreted by another



Fig. 79.—Hind limb of Chimpanzee. *i* Innominate bone; *f* Thigh-bone, or femur; *t* Tibia; *s* Fibula; *r* Bones of the ankle, or tarsus; *m* Metatarsus; *p* Phalanges.

gland called the "pancreas." The small intestine finally opens into a tube of much larger diameter, which is called the "large intestine" (*lm*). The large intestine always terminates in a distinct vent, by which the indigestible portions of the food are got rid of.

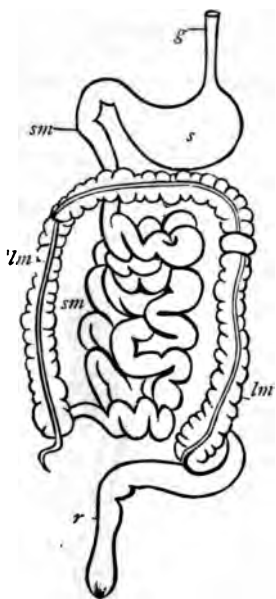


Fig. 80.—Digestive system of a Mammal. *g* Gullet; *s* Stomach; *sm* Small intestine; *lm* Large intestine; *r* Termination of the large intestine.

The result of the entire process of the digestion of the food is the formation of a nutritive fluid, the *blood*. With the single exception of one little fish (the Lancelet), the blood in all Vertebrate animals is red in colour, when viewed in mass. This is due to the presence in it of innumerable microscopical particles, which are termed the "blood-corpuscles," the fluid in which these float being colourless, or nearly so. In the subjoined illustration are represented some of the forms of blood-corpuscles which are found in different classes of the *Vertebrata*. The blood is always distributed through the body by means of a system of closed tubes which constitute the "blood-vessels;" and in all, except the Lancelet, it is propelled by a contractile muscular cavity or "heart."

Distinct *breathing-organs* are present in all the Vertebrates, but the nature of these differs according with the mode of life.



Fig. 81.—Blood-corpuscles, magnified. *a* Man; *b* Goose; *c* Crocodile; *d* Frog; *e* Skate.

In the aquatic or semi-aquatic Fishes and Amphibians, there are always *gills* or *branchiæ*, adapted for breathing air dissolved in water. Hence these classes are often spoken of collectively as the "Branchiate" Vertebrates. Some of the Fishes, how-

ever, have lungs as well as gills, and in all the Amphibians lungs are finally developed, either in addition to the branchiæ or to their total exclusion. The Reptiles, Birds, and Mammals, on the other hand, never possess gills, and they are therefore often spoken of as the "Abranchiate" Vertebrates. In place of gills they possess *lungs*, in the form of spongy organs, which are placed in the chest, and receive air through a tube opening in the throat, and termed the "windpipe" or *trachea*.

The *nervous system* varies very much in its development in different Vertebrates. In the singular little fish the Lancelet, the main mass of the nervous system consists of a cord of nervous matter, representing the spinal cord, but not enlarged in front into a distinct brain. In all other Vertebrates the central masses of the nervous system consist of a nervous cord (the spinal cord), which is contained in the canal formed by the arches of the vertebræ, and of a larger or smaller mass of nervous matter, which is placed in front of the spinal cord, is termed the "brain," and is contained within the skull. Part, however, of what is commonly called the "brain" really belongs to the spinal cord.

Reproduction in all Vertebrate animals is by means of the sexes, which are always in different individuals; and in no case are compound organisms or colonies produced by budding or cleavage. Most are *oviparous*, producing eggs, from which the young are produced; but some retain the eggs within the body till the young are ready to be hatched, and these are sometimes said to be *ovo-viviparous*. The higher Vertebrates, however, bring forth their young alive, and are said to be *viviparous* (Lat. *vivus*, living; and *pario*, I bring forth).

The sub-kingdom Vertebrata is divided into the following five great classes:—

1. *Pisces* (Fishes).
2. *Amphibia* (Frogs, Newts, &c.)
3. *Reptilia* (True Reptiles).
4. *Aves* (Birds).
5. *Mammalia* (Mammals).

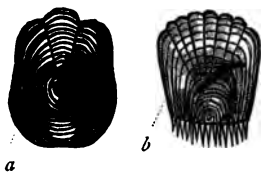
CHAPTER XVII.

CLASS I. PISCES.

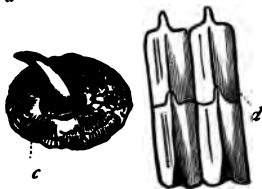
THE Fishes form the lowest class of the *Vertebrata*, and they are distinguished by being cold-blooded, by being always possessed of gills, and by having their limbs, when present, in the form of fins or expansions of the integument.

The body in fishes is mostly so shaped as to allow of rapid movement in their natural element, water, and it is generally covered with a protective covering of scales. These integumentary appendages differ a good deal in shape, but four principal kinds have been distinguished and named by the celebrated naturalist Agassiz :—

1. *Cycloid* scales (fig. 82, *a*), consisting of thin, horny, flexible scales, having a smooth rounded outline. These scales occur in most of our common fishes.



2. *Ctenoid* scales (fig. 82, *b*), resembling the last in texture, but having their hinder margin fringed with spines or comb-like projections.



3. *Placoid* scales (fig. 82, *c*), consisting of scattered bony grains, tubercles, or plates, which are often armed with projecting spines. A good example of these is to be found in the common Thornback.

4. *Ganoid* scales (fig. 82, *d*), composed of two layers, an under layer of bone, and an upper layer of hard polished enamel. These scales are not common amongst

Fig. 82.—Scales of Fishes. *a* Cycloid scale (Pike); *b* Ctenoid scale (Perch); *c* Placoid scale (Thornback); *d* Ganoid scale (*Palæoniscus*).

existing fishes, but examples are found in the Pipe-fish of our own seas and the Bony Pike of North America.

The true internal skeleton of fishes is very complicated, and little can be said about it here. In many fishes the vertebral column never becomes converted into bone, or only very partially so, but remains in its original condition of cartilage or gristle. This is the case with the Lampreys, the Skates, Sturgeons, and many others. In most ordinary fishes, however, the spinal column (fig. 83) becomes converted into bone, and,

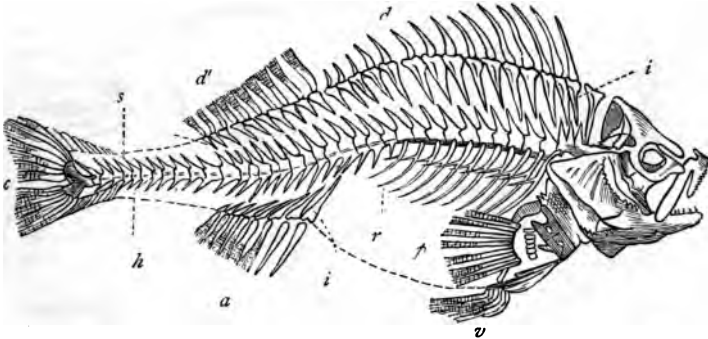


Fig. 83.—Skeleton of the common Perch (*Perca fluviatilis*). *p* One of the pectoral fins; *v* One of the ventral fins; *a* Anal fin, supported upon interspinous bones; *c* Caudal fin; *d* First dorsal fin; *d'* Second dorsal fin; *i* *i* Interspinous bones.

with one exception, the vertebræ are always cup-shaped or hollow at both ends. The result of this is, that there is formed between each pair of vertebræ a doubly-conical cavity, which is filled with a gelatinous substance; and in this way extreme flexibility is given to the whole spinal column.

The *limbs* of fishes may be wholly absent, or there may be only one pair, but there are never more than two pairs. The limbs of fishes, with the exception of the Mud-fish, are converted into *fins*, and hence they differ very much in form and structure as compared with the limbs of the higher Vertebrates. They consist, namely, of expansions of the integument, supported by numerous bony or gristly supports or rays (fig. 84); this structure rendering them capable of striking against the water, and thus of acting as swimming-paddles. The pair of limbs which corresponds to the arms of man and the fore limbs of other Vertebrates are placed on the "shoulders" of the fish, just behind the gill-slits, and they are termed the *pectoral* fins (fig. 83, 84, *p*). The hind limbs in fishes are very variable in

their position, and they are called the *ventral* fins (figs. 83, 84, *v*).

As the pectoral and ventral fins represent the fore and hind limbs, it follows that, when they are present at all, there are always *two* of each. They are therefore spoken of as the

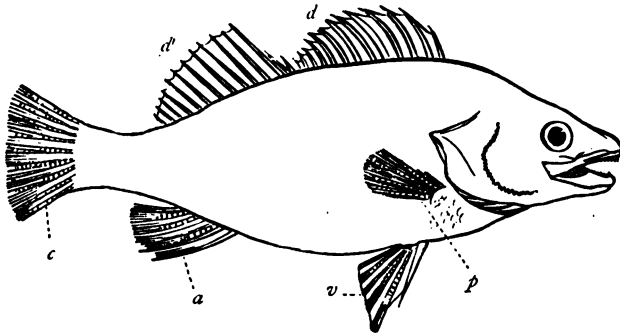


Fig 84.—Outline of a Fish (*Perca granulata*), showing the “paired” and “median” fins. *p* One of the pectoral fins; *v* One of the ventral fins; *d* First dorsal fin; *d'* Second dorsal fin; *a* Anal fin; *c* Caudal fin.

“paired” fins. Besides these, however, there is also a series of what are called “median” fins, which must in no way be confounded with the paired fins. The median fins are placed in the middle line of the body, and they are *unpaired*, having no fellows. They agree with the paired fins in consisting of expansions of the integument supported by “rays,” but they differ from them in the fact that their rays are carried upon the heads of a peculiar series of bones, known as the “interspinous bones” (fig. 83, *i i*). These are dagger-shaped bony spines which are embedded in the middle line of the body of the fish. The “median” fins are variable in number, and sometimes there is only a single fringe running round the hinder end of the body. Commonly, however, the median fins consist of one or two expansions placed upon the back, and called the “dorsal” fins (fig. 84, *d, d'*); one or two upon the lower surface near the vent, called the “anal” fins (*a*); and a broad fin clothing the extremity of the spinal column, and known as the “caudal” fin or tail (*c*). The tail-fin is the chief organ of progression of the fish, and it is placed vertically, so as to strike the water from side to side, and not horizontally, as in the Whales and Dolphins. In most living fishes the tail is composed of two

equal lobes which spring from the end of the spine (fig. 85, *a*), when it is said to be "homocercal." In a few living fishes, however, and in many fossil forms, the tail is unsymmetrical, being unequally lobed (fig. 85, *b*). In these cases the spinal column is prolonged into the upper lobe of the tail, and the tail is said to be "heterocercal."

As regards the digestive system of fishes, the mouth is usually furnished with a very complicated series of teeth, which are placed not only upon the jaws, but often upon any or all of the bones which enter into the composition of the mouth. The intestinal canal is usually short, but the liver is usually of large size and saturated with oil.

In all fishes except the Lancelot, the breathing-organs are in the form of gills or branchiæ, the exact form and arrangement of these differing considerably in different fishes. In most fishes, however, the gills are in the form of a number of pointed leaflets arranged on bony or cartilaginous arches which are connected with the tongue-bone below and with the lower surface of the head above. The gills are placed in a chamber on each side of the neck of the fish, and the water is admitted to them from the mouth by a series of openings or fissures in the throat. The water is taken in by a process very like that of swallowing, and, after passing over the gills, it makes its escape behind by a single opening on the side of the neck, called the "gill-slit." The gill-slit can be opened at will, and is covered in by a kind of folding-door composed of a chain of flat bones, called the "gill-cover." The gill-slit is also partially covered below by a membrane supported upon a variable number of slender bony spines.

Whilst respiration in all the typical fishes is carried on by means of gills, most are, nevertheless, furnished with an organ which is called the "swim-bladder" or "air-bladder," and doubtless corresponds to the lungs of the higher Vertebrata. It is placed below the spine, and is filled with gas, doubtless acting mainly as a kind of float. Sometimes it is quite closed,

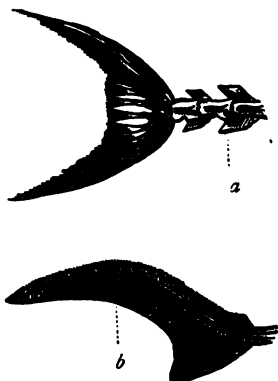


Fig. 85.—Tails of different Fishes.
a Homocercal tail (Sword-fish); *b* Heterocercal tail (Sturgeon).

but in other cases it opens into the gullet by a tube which corresponds with the windpipe. In the Mud-fish (*Lepidosiren*) the air-bladder is double, and is actually concerned with carrying on the function of respiration, so that in this fish the air-bladder truly becomes a lung.

The heart in fishes mostly consists of only two chambers, and is concerned with driving the impure or venous blood to the heart. The blood is cold—that is to say, little or not at all warmer than the medium in which the animal lives. The blood-corpuscles (fig. 81, *c*) are furnished with a solid particle in their interior, or are “nucleated,” and, except in the Lancelet, most of them are red.

The nervous system is of a comparatively low type of organisation, and the brain is of small size. The essential parts of the organ of hearing are always present, but in none is there any direct communication between the ear and the outer world, though sometimes traces of such may be detected. The nose does not open behind into the throat, except in the Hag-fishes and the Mud-fish, and the sense of smell must be far from acute.

Lastly, as regards their mode of reproduction, most fishes are truly *oviparous*, but some are *ovo-viviparous*. The ovaries of the female fish are commonly called the “roe.”

CHAPTER XVIII.

ORDERS OF FISHES.

THE known number of fishes is so great, and their forms and habits so various, that it will be sufficient merely to give the leading peculiarities of the six orders into which the class is divided. The classification here adopted is the one proposed by Professor Huxley.

ORDER I. PHARYNGOBRANCHII (Gr. *pharugx*, the upper part of the gullet; *bragchia*, gill).—This order includes only a single little fish, the Lancelet (*Amphioxus*), the characters of which differ very greatly from those of the more highly organised Fishes. The Lancelet is a little, worm-like, semi-transparent fish, from one and a half to two inches long, found burrowing in sand-banks in various seas. It has no "paired" fins, representing limbs, but there is a narrow median fin and a lancet-shaped caudal fin. There are no jaws or teeth, but the mouth is surrounded by a number of cartilaginous filaments. The mouth opens into a great chamber, the walls of which are perforated by numerous ciliated slits or fissures. This sac acts as a breathing-organ, and takes the place of gills. There is no heart, but the blood is propelled by pulsating dilatations of several of the great blood-vessels. The blood itself is colourless. There is no vertebral column, but the spinal cord rests upon a semi-gelatinous rod (notochord); and the spinal cord does not expand in front so as to form a distinct brain.

ORDER II. MARSIPOBRANCHII (Gr. *marsipos*, a pouch; *bragchia*, gill).—This order includes the eel-like Lampreys and Hag-fishes (fig. 86), and derives its name from the pouch-like arrangement of the gills. The gills, namely, are not placed all together in a chamber on each side of the neck, as in most common fishes, but they are situated in a number of distinct sacs or pouches (fig. 86, B), which receive water from the throat, and

open externally by a number of separate openings placed on the side of the neck. This arrangement allows these fishes to fix themselves to any solid object by their mouths, as they are not obliged to take in water by the mouth. There is no lower jaw in these fishes, and the mouth forms a kind of sucking-cup. There are no pectoral or ventral fins, or, in other words, there are no limbs. The skull is cartilaginous, and the vertebral column is only represented by the notochord.

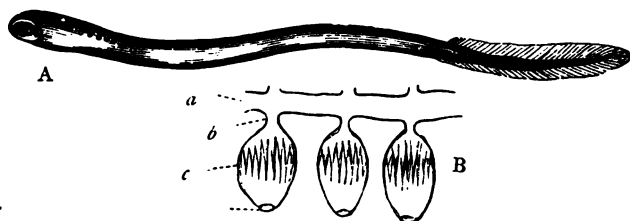


Fig. 86.—A, Lamprey (*Petromyzon*), showing the sucking-mouth, and the apertures of the gill-sacs. B, Diagram showing the arrangement of the gills in the Lampreys.

The Hag-fish (*Myxine*) is an eel-like fish, which is generally found embedded in the interior of some large fish, into which it has penetrated by means of a single serrated fang attached to the centre of the palate. A curious fact about the Hag-fish is that the nose communicates with the mouth by a tube which perforates the palate.

The Lampreys are found both in fresh and salt water; some of them are often eaten. In these, the cavity of the nose is closed, and does not communicate behind with the throat, as is the case in the Hag-fishes.

ORDER III. TELEOSTEI (Gr. *teleios*, perfect; *osteon*, bone).—This order comprises the so-called "Bony" fishes, including most of the commoner forms of the class. As implied by their name, the skeleton is generally completely bony, and there is a vertebral column consisting of distinct vertebræ, hollow at both ends. The Bony fishes are the most typical members of the class, and most of their peculiarities have been mentioned in speaking of the fishes generally. It will be enough, therefore, to state here, that in addition to the characters just mentioned, the Bony fishes are distinguished by the following points: 1. The skull consists of distinct bones, and a lower jaw is present.

2. The scales are mostly "cycloid" and "ctenoid," and are only rarely "ganoid." 3. The fore and hind limbs are usually, but not always, present, when they are known as the pectoral and ventral fins. 4. Median fins exist besides the paired fins. 5. The tail consists of two equal lobes, or is "homocercal." 6. The respiratory organs are in the form of comb-like or tufted gills placed in two chambers situated on the sides of the neck. Each gill-chamber opens externally by a single vertical "gill-slit," protected by a "gill-cover," and a membrane supported by bony rays. 7. The nose does not communicate behind with the throat.

Amongst the more important families of this large order of fishes may be mentioned the Eels (*Muraenidae*), the Herrings (*Clupeidae*), the Pikes (*Esocidae*), the Salmon and Trout (*Salmonidae*), the Cod and Haddock family (*Gadidae*), the Flat-fishes (*Pleuronectidae*), the Perch family (*Percidae*), and the Mackerels (*Scomberidae*).

ORDER IV. GANOIDEI (Gr. *ganos*, splendour or brightness).—The Ganoid fishes agree with the Bony fishes in the form of the gills and gill-covers, but the ossification, or conversion into bone, of the skeleton is imperfect; and the body is protected externally by *ganoid* scales or plates—*i.e.*, by scales consisting of

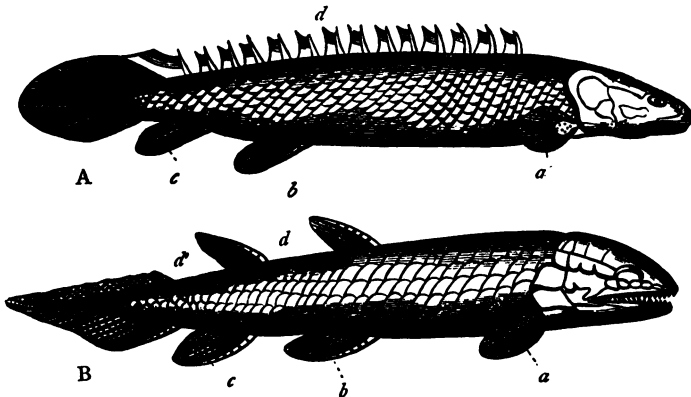


Fig. 87.—Ganoid Fishes. A, *Polypterus*, a living Ganoid. B, *Osteolepis*, a fossil Ganoid. a Pectoral fin; b Ventral fin; c Anal fin; d, d', Dorsal fins.

an inferior layer of bone, and a superior layer of polished enamel (fig. 87). These ganoid scales are not peculiar to the Ga-

noid fishes, but are very characteristic of them. The skull in the Ganoids is composed of distinct bones, and there is a lower jaw. The pectoral and ventral fins are usually present, and the latter are placed very far back. The tail-fin is unsymmetrical or "heterocercal."

There are few living Ganoid fishes, but very many fossil forms are known to geologists. Of the living forms the best known are the *Polypterus* (fig. 87, A) of the rivers Nile and Senegal, the Bony Pike of North America, and the Sturgeons. The true Sturgeons are the most familiar and most important of the living Ganoids. They mostly attain a very large size, and are chiefly found in the North Sea, the Caspian, and the Black Sea, being captured when ascending the great rivers for the purpose of spawning. The swim-bladder of the Sturgeons is

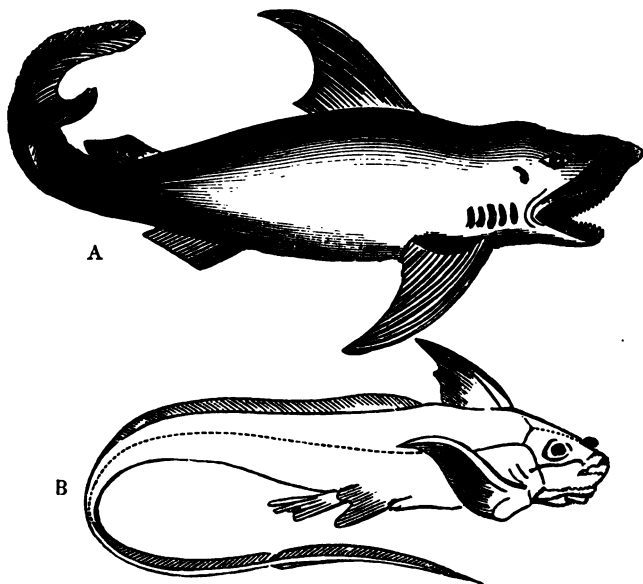


Fig. 88.—A, White Shark (*Carcharias*); B, *Chimera*.

one of the chief sources from which *isinglass* is prepared; and the roe is largely sold as a delicacy under the name of *caviare*.

ORDER V. ELASMOBRANCHII (Gr. *elasma*, a thin plate; *brachia*, gill).—The best-known members of this order are the Sharks and Rays, and the leading character of the order is to be found in the nature of the gills, which are fixed, and form a number of pouches. These pouches communicate internally with the throat, and in most cases open externally on the side of the neck by means of as many apertures as there are pouches (fig. 88, A). In some cases, however, as in the *Chimera* (fig. 88, B), though the structure of the gills is the same, there is only a single external aperture. The skull is not composed of distinct bones, the vertebral column is usually cartilaginous, and the skin is furnished with *placoid* scales—*i.e.*, with detached bony tubercles, granules, or plates. The pectoral and ventral fins are present, and the latter are placed very far back.

In the Sharks and Rays the mouth is placed on the under surface of the head, and there are several apertures to the gills. In the *Chimera* and its allies the mouth is placed at the end of the head, and there is only a single external gill-aperture. The Sharks and Dog-fishes are common in all oceans, and are extremely voracious animals. The Rays are distinguished from the Sharks by having a flattened body, and some of them attain an enormous size.

ORDER VI. DIPNOI (Gr. *dis*, twice; *pnoē*, breath).—This order includes only the singular Mud-fishes (*Lepidosiren*, fig. 89),



Fig. 89.—Mud-fish (*Lepidosiren annectens*). *p* Pectoral limbs; *v* Ventral limbs.

which are natives of South America and Africa. The name of the order is derived from the fact that the respiratory organs are twofold, consisting of gills and of true lungs. In this respect the Mud-fishes approach the next class of the Amphibians, and the resemblance is further increased by the fact that some of the Mud-fishes possess *external* gills, as well as the internal set. The nose, also, opens behind into the throat, as is the case in no other fishes except the Hag-fishes.

The body in the Mud-fish is fish-like and covered with scales, the two pairs of limbs are present in the form of shaped organs, and the tail is furnished with a vertical fin. The Mud-fishes inhabit marshy tracts, and appear able during dry season to bury themselves in the mud, and to form a nest in which they remain dormant till the rains of the season set them free.

CHAPTER XIX.

CLASS II. AMPHIBIA.

THE class *Amphibia* comprises the Frogs and Toads, the Newts and Land-salamanders, the *Cæcilia*, and some extinct forms; and the great and distinguishing character of the class is the fact that the animal undergoes a kind of change or metamorphosis in passing from the young to the adult condition. In the great majority of cases, as in the common Frog (fig. 90), the Amphibians commence life as water-breathing "larvæ," commonly known as Tadpoles. In this condition they possess a long fish-like tail, and are furnished with gills or branchiæ, adapted for breathing air dissolved in water (fig. 90, *a*, *b*). They spend a certain length of time in this fish-like condition, but

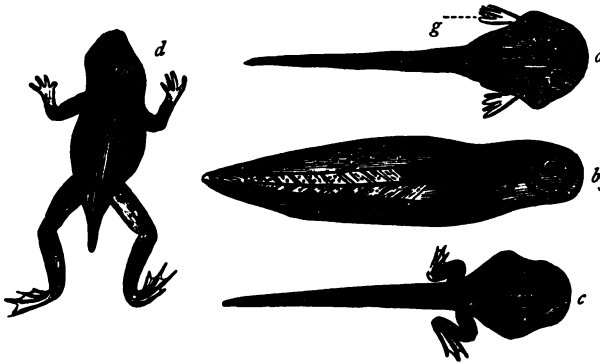


Fig. 90.—Development of the common Frog. *a* Tadpole, showing the external gills, viewed from above; *b* The same viewed from the side; *c* Older specimen, in which the hind legs have made their appearance; *d* Specimen in which all the limbs have appeared.

ultimately true lungs are always developed, and the animal then becomes capable of living on land. In some cases, as in the

Axolotl (fig. 91), the external gills are retained throughout life, and do not disappear when the lungs are developed. In other cases, again, the gills disappear when the lungs are produced, and the animal is then only capable of breathing air directly.



Fig. 91.—The Axolotl (*Siredon pisciforme*), showing the persistent external branchiae (after Tegetmeier).

This occurs in the Newts and Frogs; but another difference is observable as to the development of these. In the Newts (fig. 92), the long tail of the Tadpole or "larva" is retained throughout life, and the animal remains permanently a "tailed" Amphibian. In the Frogs and Toads, however, the larval tail is cast off before the animal attains maturity, and the adult is a "tail-less" Amphibian (fig. 93). This change from an aquatic to an aerial mode of respiration is, then, the leading character of the *Amphibia*, and it is from this that the name of the class is derived (Gr. *amphi*, both; *bios*, life). The adult, however, is obviously not strictly *amphibious*, unless, like the Axolotl, it retains its gills throughout life.

The *Amphibia*, then, are "branchiate" Vertebrates, and agree with the Fishes in always possessing gills at some time or other of their life. They differ from all the fishes, except the Mud-fish, in always possessing true lungs when grown up; and they differ from all fishes in never having the limbs converted into fins, and in never

having "median" fins supported by bony or gristly "rays." They are further characterised by the fact that the skull is jointed to the vertebral column by *two* joints (or "condyles");

the heart of the adult is three-chambered; and the nose opens behind into the throat.

The class Amphibia is divided into three living orders as follows :—

1. *Ophiomorpha*.
2. *Urodela*.
3. *Anoura*.

ORDER I. OPHIOMORPHA (Gr. *ophis*, a serpent; *morphe*, form).—This order includes only certain worm-like or snake-like Amphibians, which are termed *Cæciliæ*, and are found burrowing in marshy ground in Java, Ceylon, South America, and Guinea. They possess no limbs, and have only rudimentary eyes, and though very like the true Snakes, they have gills when young, and are therefore undoubted Amphibians. They sometimes attain a length of several feet.

ORDER II. URODELA (Gr. *oura*, tail; *delos*, visible).—This section includes the so-called “tailed” Amphibians, such as the Newts and Salamanders, in which the tail of the tadpole does not fall off when maturity is reached, but is permanently retained throughout life (fig. 92). As a general rule, both the fore and hind-limbs are developed, but the latter may be want-

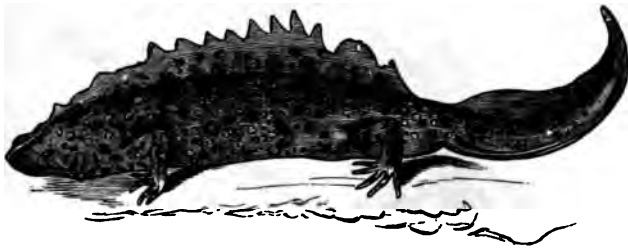


Fig. 92.—Great Water-newt (*Triton cristatus*)—after Bell.

ing. Owing to the presence of two pairs of limbs and a long tail, the *Urodela* are not uncommonly confounded with the *Lizards*; but the latter are true Reptiles, and never possess gills at any time of life.

In some of the *Urodela* the gills are permanently retained throughout life, as is the case with the Axolotl (fig. 91). This curious Amphibian inhabits the Mexican lakes, and attains a length of a foot or more. More remarkable than the Axolotl,

and also keeping the gills throughout life, is the *Proteus*, which is found inhabiting the waters of certain caves in Illyria and Dalmatia. It attains a length of about a foot, and from its living in darkness the eyes are completely rudimentary.

In other *Urodela*, as in our common Newts (fig. 92), the gills disappear before maturity is reached, and both pairs of limbs are always present. The Newts are adapted for an aquatic life, and have a compressed fish-like tail. Several species are known as inhabiting our own country, and every one probably is acquainted with their appearance. The Land-salamanders are nearly related to the Newts, but they live upon the land, and have a rounded cylindrical tail.

ORDER III. ANOURA (Gr. *a*, without; *oura*, tail).—This order comprises the Frogs and Toads, or so-called "tail-less" *Amphibia*, the adult wholly losing the long tail which is present in the young (fig. 93). The adult is also destitute of gills, and respiration is carried on wholly by the lungs, assisted to a greater or less extent by the skin. The young, however, or tadpoles, have gills, and possess a long fish-like tail (fig. 90).



Fig. 93.—Tree-frog (*Hyla leucotania*)—after Günther.

In the Toads (*Bufonidae*) there is a tongue, but the jaws are not armed with teeth. In the Surinam Toads (*Pipidae*) there are rarely teeth, and there is no tongue. In the true Frogs (*Ranidae*) the upper jaw always carries teeth, and there is a

tongue, like that of the Toads, fixed to the front of the mouth, and free behind, so that it can be protruded at will. The typical Frogs have enormously-developed hind legs, the toes of which are united by membrane, or are "webbed." They swim very powerfully, and can take extensive leaps. The Tree-frogs (fig. 93), on the other hand, are adapted for a wholly different life, inhabiting trees, amongst which they climb with great ease by the help of suckers developed upon the ends of all the toes. They are mostly found in warm countries, especially in America, but one species is European.

CHAPTER XX.

CLASS III. REPTILIA.

WITH the true Reptiles we commence the series of the "abran-
chiate" Vertebrates, or of those Vertebrate animals which never
at any time of life are possessed of gills or branchiæ. The
blood is cold, like that of the preceding classes, and the blood-
corpuscles are nucleated (fig. 81, *c*). The heart in most
Reptiles is three-chambered, but is sometimes four-chambered.
In all, however, the body is not supplied with pure arterial
blood, but with a mixture of arterial with impure venous blood;
hence the low temperature and generally sluggish character of
these animals. The skull in the true Reptiles, unlike that of
the *Amphibia*, is united to the vertebral column by a single
joint (or condyle), and each half of the lower jaw is composed
of several pieces. The skin has the power of secreting horny
scales, with or without bony plates, but in no case do the appen-
dages of the integument take the form of feathers. The limbs
may be altogether wanting, as in the Snakes—or rudimentary,
as in some Lizards; but in most Reptiles both pairs of limbs
are present. In no case, however, are the fore limbs con-
structed upon the type of the "wing" of Birds. Lastly, all
Reptiles are oviparous or ovo-viviparous.

The class *Reptilia* is divided into four living and five extinct
orders, of which the former only will be considered here. The
living orders are:—

1. *Chelonia* (Tortoises and Turtles).
2. *Ophidia* (Snakes).
3. *Lacertilia* (Lizards).
4. *Crocodylia* (Crocodiles).

ORDER I. CHELONIA.—The members of this order are well
known as Tortoises and Turtles, and are characterised by the
fact that the jaws are not provided with teeth, and the body is
enclosed in a double bony case or box. The jaws in all the

Chelonians are encased in horn, so as to constitute a kind of beak like that of a bird, and in only a few instances are lips present. The case in which the body is protected is double, and is composed partly of flattened bones belonging to the true skeleton and partly of bony or horny plates developed in the integument, or of a leathery skin. The case is essentially made up of a superior shield called the "carapace" (fig. 94, *ca*), and a

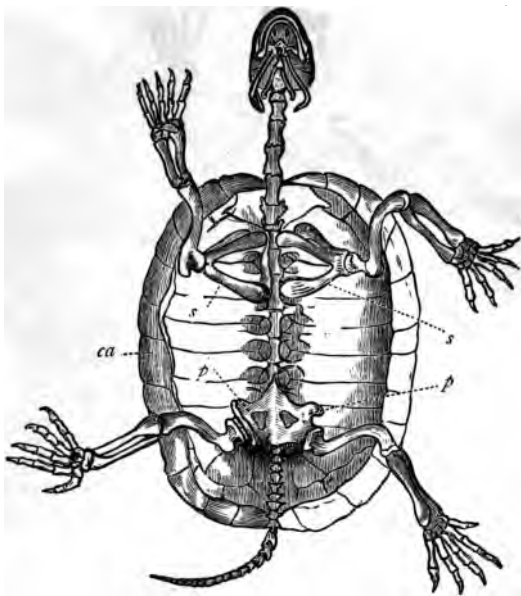


Fig. 94.—Skeleton of a Tortoise, seen from below, the plastron having been removed. *ca* Carapace.

lower or ventral shield, called the "plastron." The carapace and plastron are united along their edges, but leave apertures for the protrusion of the head, tail, and limbs; and the bones connecting the limbs with the spine are placed under the carapace.

The Chelonians are conveniently divided into groups, according as the limbs are adapted for swimming, for progression on land, or for an amphibious life. The aquatic forms are well known as Turtles, distinguished by having the carapace de-

pressed, and the limbs converted into oar-like flippers, with which the animal swims. The two most important of the Turtles are the edible Green Turtle and the Hawk's-bill Turtle (fig. 95). The former of these is found in many of the seas of

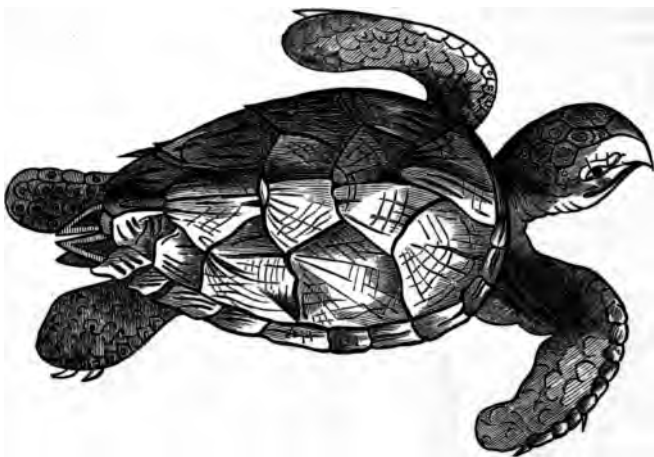


Fig. 95.—Hawk's-bill Turtle (*Chelonia imbricata*)—after Bell.

warm climates, and is largely imported into Europe as a delicacy. The latter is of considerable commercial value, from the horny scales which cover the carapace, and which are so largely employed for ornamental purposes under the name of "tortoise-shell."

The Land-tortoises have a rounded and convex carapace, with indistinct toes furnished with short claws. The most familiar species in this country is the *Testudo Græca*, which is often kept as a domestic pet.

The Pond and River Tortoises are furnished with webbed feet, and lead a semi-aquatic existence. The latter have the carapace covered with a leathery skin, without horny scales, and are therefore often called "Soft Tortoises."

ORDER II. OPHIDIA.—This order includes most of the animals which would commonly be called Snakes or Serpents, the most striking peculiarities of which are to be found in the nature of the organs of locomotion. The body is always more or less elongated, worm-like, or cylindrical (fig. 96), and there

are no visible limbs. The fore-limbs are altogether and universally wanting, and the hind limbs are almost always also absent. In a few cases, however, there are rudimentary traces of the existence of hind limbs. There is never any breast-bone, but the ribs are exceedingly numerous, and the Snakes progress rapidly by means of these, walking, as it were, upon the ends of the ribs, the great flexibility of the vertebral column much assisting in this. The skin in the Snakes develops horny scales, but bony plates are never produced in it.

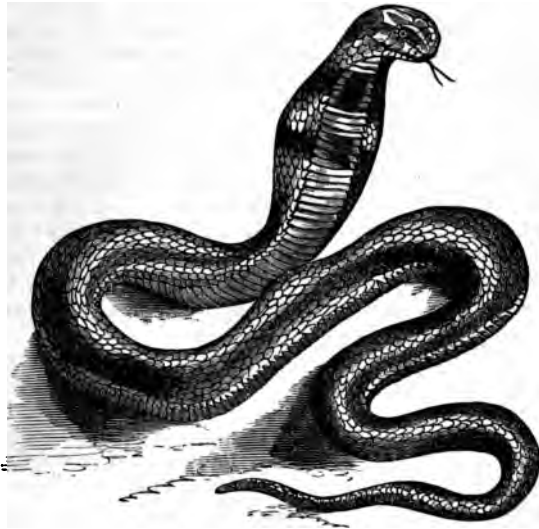


Fig. 96.—The *Naja Haje*, a poisonous snake of Egypt.

The tongue in Serpents is forked, and consists of two muscular cylinders united towards their bases. It can be protruded and retracted at will, and is probably more an organ of touch than of taste. The eye in Serpents is not protected by movable eyelids, but is covered by a pellucid membrane composed of the outer layer of the skin; hence the fixed and unwinking stare of these animals.

Hooked conical teeth are always present, but they are not sunk in distinct sockets, and are only used to hold the prey, and not in chewing it. All the arrangements of the mouth in Serpents are adapted to the fact that they live upon animals which

they catch, and that they swallow their food without dividing it or chewing it. To this end the two halves of the lower jaw are merely loosely united to one another by ligaments and muscles; they are connected with the skull by a bone, which is also movable. The result of this is, that the Snakes can open the mouth to an extraordinary width, and they can perform the most astonishing feats in the way of swallowing. In the harmless Snakes the teeth are solid, and are arranged in rows in both jaws and on the palate. In the poisonous Snakes, on the other hand, the upper jaws are usually destitute of the ordinary solid teeth, but carry a pair of long curved "poison-fangs." The poison-fangs are pointed backwards when not in use, but they can be erected at will by muscular action the moment the animal wishes to bite. Each poison-fang is hollow, and is perforated by a fine tube or canal, opening by a distinct aperture at the point of the fang. The canal of the fang communicates with a gland placed under and behind the eye, which secretes the fluid which renders the bite of these Snakes dangerous or deadly. When the animal strikes its prey, the poison-fangs are erected, and as their points enter the flesh a drop of fluid is forced through the canal of the fang into the wound. In some venomous serpents, however, and in some not certainly known to be venomous, there are large grooved fangs, which are not pierced by a distinct canal.

Of the non-venomous harmless Snakes, we have an excellent example in the common Ringed Snake (*Coluber natrix*) of this country. It lives upon small animals, such as Frogs, and often takes to the water, swimming rapidly and gracefully. In this respect, however, it is excelled by the poisonous Water-snakes (*Hydrophidae*), which live in flocks at the mouths of rivers, and are specially adapted to an aquatic life by the possession of a compressed swimming-tail. Some of the non-venomous Snakes are rendered highly dangerous by their great size and enormous muscular power. Their bite is harmless, but they kill their prey by coiling themselves round it and gradually tightening the folds. Of this nature are the Pythons and Boas of hot climates, which are certainly known to exceed twenty feet in length, and which are said sometimes to attain a much greater size.

The poisonous Snakes are familiarly known to us by the common Viper (*Pelias berus*), which occurs commonly in this country. It is a harmless animal, unless trodden on or otherwise irritated, and its bite, though dangerous, is rarely fatal. Other notorious venomous Serpents are the Rattlesnake of

America, the Hooded Snake of India, and the Puff-adder of South Africa.

ORDER III. LACERTILIA.—This order comprises the ordinary Lizards, and some snake-like animals, such as the Blind-worm of Britain. The *Lacertilia* are distinguished from the Snakes by *usually* having four well-developed limbs, and by the fact that the two halves of the lower jaw are united in front much more firmly than in the Ophidians. The eyes, too, are mostly furnished with movable eyelids. The Lizards are distinguished, on the other hand, from the Crocodiles, by not having their teeth implanted in distinct sockets, and by the fact that the skin develops horny scales, but never bony plates.

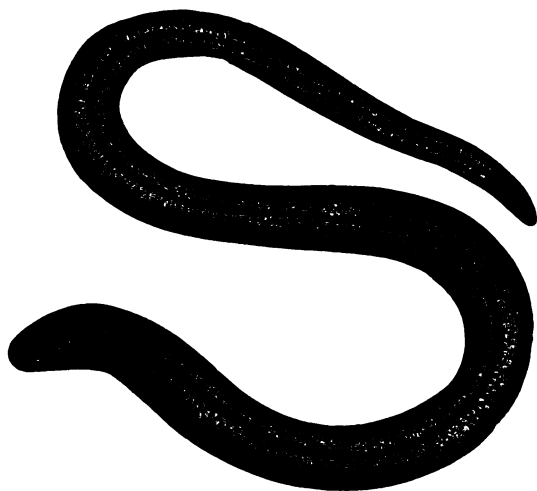


Fig. 97.—Blind-worm (*Anguis fragilis*)—after Bell.

Of the snake-like Lizards a good example is to be found in the common Blind-worm or Slow-worm (fig. 97) of our own country. Its appearance is completely snake-like, and it is vulgarly regarded as a dangerous and venomous animal. It is, however, perfectly harmless and inoffensive, not even having the power of piercing the human skin. It lives upon worms, insects, and snails, and can be easily kept in captivity. It is remarkable in the fact that when alarmed it stiffens its muscles

to such an extent that the tail can readily be broken off, as if it were brittle.

As a good example of the typical Lizards with four well-developed legs, we may take the Skink (fig. 98), which is ex-

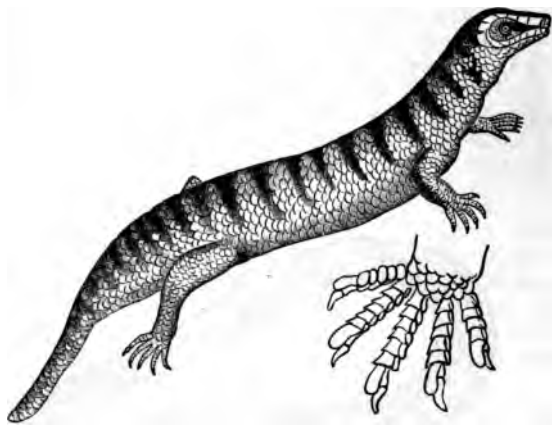


Fig. 98.—The Skink (*Scincus officinalis*).

tremely common in Egypt and Arabia. It is from eight to nine inches in length, and was formerly used as a remedy in various diseases. The only Lizard, except the Blind-worm, which can be said to be at all common in England, is the Sand-lizard (*Lacerta agilis*), but this is also of small size. The largest of the living Lizards are the Monitors, which are exclusively found in the Old World, and attain a length of from six to eight feet. Very large, too, are the Iguanas of the American continent, which often reach a length of several feet.

ORDER IV. CROCODYLIA.—The *Crocodylia* are distinguished from other Reptiles by the possession of teeth implanted in separate sockets, and by the fact that the skin not only develops horny scales, but in addition produces bony plates, which form a covering for the upper surface of the body.

The Crocodiles abound in the fresh waters of hot climates, and are the largest of existing Reptiles, not uncommonly attaining a length of sixteen feet or more. The best known of the *Crocodylia* is the Nilotic Crocodile, which occurs abundantly in Egypt, and was described by both Herodotus and Aristotle.

Little less familiar are the Alligators or Caimans, which often attain a length of fourteen feet, and are of common occurrence in many parts of America. The smallest of the living Crocodiles is the Gavial or Gangetic Crocodile of Hindostan,

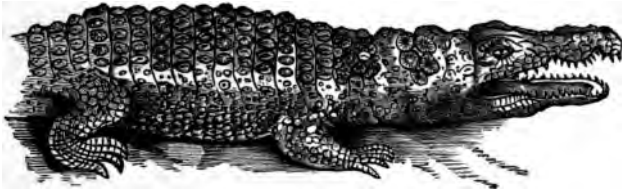


Fig. 99.—Head and fore part of the body of the common Crocodile
(*Crocodilus vulgaris*).

which attains a length of about ten feet. All the Crocodiles are dangerous and voracious brutes, and many instances are on record in which human beings have been injured or killed by them in crossing rivers or in bathing.

CHAPTER XXI.

CLASS IV. AVES.

THE fourth class of Vertebrate animals is that of the Birds or *Aves*, which may be shortly defined as being "oviparous Vertebrates, with warm blood, a double circulation, and a covering of feathers" (Owen). Besides these characters, the majority of the blood-corpuscles are nucleated (fig. 81, *b*), the skull is jointed to the spinal column by a single joint (condyle), the jaws are destitute of teeth, the fore limbs are modified so as to form "wings," and the lungs communicate with a number of air-sacs scattered through the body.

The feathers, which form such a distinctive character of Birds, are formed by a modification of the outer layer of the skin; and a typical feather, such as one of the quill-feathers of the wing or tail, consists of the following parts: 1. A horny cylindrical tube, which forms the lowest part of the feather, and is termed the "quill." 2. The "shaft," which forms the central axis of the feather, and consists of a horny sheath filled with a white spongy substance. 3. The "webs," which form the lateral expansions of the feather, and are attached to the sides of the shaft. Each web is composed of a number of small branches or "barbs," which in turn carry still smaller fibres or "barbules." As a rule, the barbs are kept in connection with one another by means of the barbules, the ends of which are hooked. Towards the base of the shaft, however, the barbs are more or less separate, and constitute what is known as the "down." In the Ostriches, and the birds allied to them, all the barbs are separate from one another, and approach to the characters of hairs.

The skeleton of Birds exhibits many points of peculiar interest, mostly in adaptation to an aerial mode of life; but it will be sufficient here to notice the structure of the fore limb or "wing," and the bones by which the fore limb is connected with the trunk (fig. 100, A). The breast-bone (*b*) in all birds

which fly is furnished with a prominent ridge or "keel," to which are attached the great muscles which move the wings. The size, therefore, of this keel gives a good indication of the

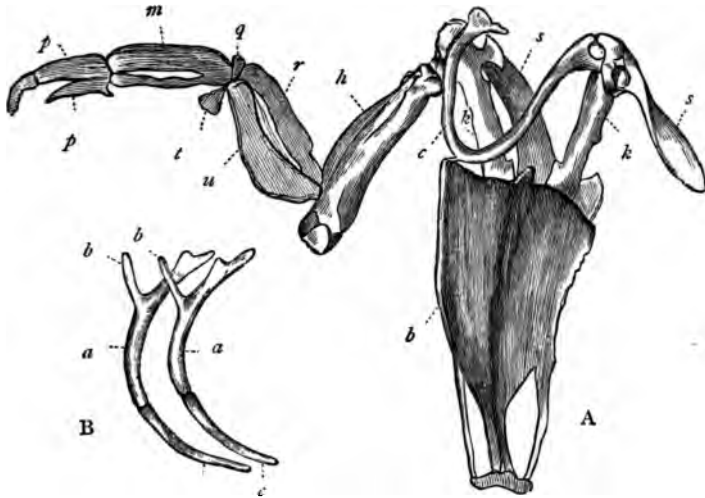


Fig. 100.—A, Breast-bone, shoulder-girdle, and fore limb of Penguin (after Owen): *b* Breast-bone with its keel; *s s* Shoulder-blades; *k k* Coracoid bones; *c* Furculum or merry-thought, composed of the united collar-bones; *h* Humerus; *r* Radius; *u* Ulna; *q* Wrist; *t* Thumb; *m* Metacarpus; *p* Phalanges of the fingers. B, Ribs of the Golden Eagle.

strength of flight in any given instance; and in birds which do not fly, like the Ostrich, there is no keel upon the breast-bone. The bones which connect the fore limbs with the trunk are the two shoulder-blades, the two "coracoid bones," and the so-called "furculum" or "merry-thought." The two shoulder-blades (*s s*) exhibit no special peculiarity. The so-called "coracoid bones" are the representative of what is part of the shoulder-blades in most mammals; but in Birds they are not only separate bones, but are the strongest bones of the shoulder-girdle. They form two strong pillars (*k k*), which rest upon the breast-bone below, and support the downward stroke of the wing. The "furculum" or "merry-thought" (*c*) is a V-shaped bone, which keeps the wings at their proper distance from each other, and which is really composed of the united collar-bones or clavicles. The bone of the upper arm or humerus (*h*), and the bones of the forearm or radius and ulna (*r, u*) offer no special

peculiarity. The wrist or carpus (*g*) is, however, reduced to two small bones; the metacarpus (*m*) is also reduced to two bones, which are joined at their extremities; and the digits are reduced to a rudimentary thumb (*t*) and two fingers (*p*). (To understand the differences between the fore limb of a Bird and that of a Mammal, the student should refer to the general description of the limbs of Vertebrates, p. 114, fig. 78.)

There are no teeth in Birds, and the jaws are sheathed in horn, constituting the "beak." The tongue is usually hard and horny, but is sometimes soft and fleshy, as in the Parrots. The gullet (fig. 101, *o*) is usually dilated in the lower part of the neck into a pouch (*c*) called the "crop." Shortly after leaving

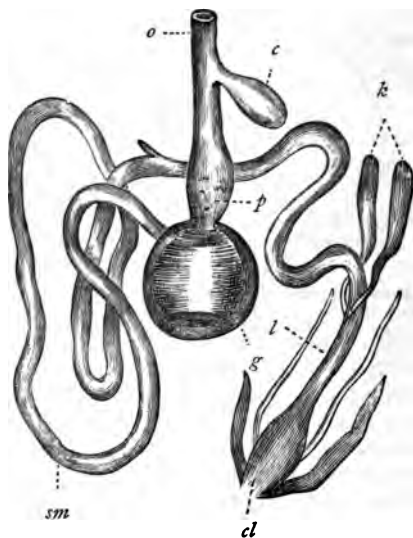


Fig. 101.—Digestive system of the common Fowl (after Owen). *o* Gullet; *c* Crop; *p* Proventriculus; *g* Gizzard; *sm* Small intestine; *ic* Intestinal caeca; *l* Large intestine.

the crop, the gullet opens into a second cavity, which is the true digesting stomach, and is called the "proventriculus" (*p*). This in turn opens into a muscular cavity which is called the "gizzard" (*g*), and which leads into the small intestine (*sm*). In those birds which live on hard substances, such as the grain-eating species, the gizzard is extremely thick and muscular, and

its inner lining is hard and horny. In these birds the gizzard constitutes a kind of grinding apparatus, like the stones of a mill; whilst the "crop" may be compared to the "hopper" of the mill, since it supplies to the gizzard "small successive quantities of food as it is wanted" (Owen). The grinding action of the gizzard is further assisted by the small pebbles and gravel, which, as is well known, so many birds are in the habit of swallowing. The commencement of the large intestine is furnished in most birds with two blind tubes or "cæca" (*k*). These vary considerably in length in different birds, and their exact function is questionable.

Respiration is effected in Birds more completely and extensively than in any other class of Vertebrate animals, in consequence of the fact that air is admitted not only to the lungs, but also to a series of air-receptacles scattered through various parts of the body. The lungs, namely, of Birds communicate with a series of membranous sacs, which vary in number and position in different cases, but serve in all alike both to reduce the specific gravity of the body, and to assist in the aeration of the blood. Further, the air is admitted from these air-receptacles into a number of air-cavities in the interior of a greater or less number of the bones. In young Birds these air-cavities in the bones do not exist, and the bones are simply filled with marrow, as in the Mammals. In Birds, also, which do not fly, there are either no air-cavities in the bones, or very few.

The heart in Birds is four-chambered, and the circulation is double, as it is in Mammals. In other words, the heart is a double organ, one side being wholly concerned with propelling the pure arterial blood through the body, whilst the other is occupied in driving the impure venous blood through the lungs.

The organs of the senses, with the exception of touch and taste, are well developed in Birds, vision especially being generally extremely acute. Eyes are always present, and the form of the eye is maintained by a circle of bony plates. In addition to the ordinary upper and lower eyelids, Birds possess a third membranous eyelid—the *membrana nictitans*—which is placed on the inner side of the eye, and can be drawn over the front of the eye like a curtain. The sense of smell is apparently seldom very acute in Birds, and the nostrils are usually placed on the sides of the upper mandible of the bill.

Finally, all Birds are strictly *oviparous*. The egg is always enclosed in a calcareous shell, and is developed after expulsion from the body by a process of "incubation" or "brooding"—a process for which Birds are especially adapted, in consequence of the high average temperature of the body.

CHAPTER XXII.

ORDERS OF BIRDS.

THE class *Aves* is divided into the following seven living orders, each of which must be briefly considered :—

1. *Natatores* or Swimming Birds.
2. *Grallatores* or Wading Birds.
3. *Cursores* or Running Birds.
4. *Rasores* or Scratching Birds.
5. *Scansores* or Climbing Birds.
6. *Insessores* or Perching Birds.
7. *Raptores* or Birds of Prey.

ORDER I. NATATORES.—The order of the Swimming Birds comprises birds which are adapted for a more or less completely aquatic life. The body (fig. 102) is boat-shaped, the neck long, and the legs short and placed behind the point of equilibrium of the body; this position admirably adapting the feet to act as oars, but rendering the gait upon dry land comparatively awkward and shuffling. The toes are always more or less completely webbed, or united to one another by a membrane. From their living much in the water, the Natatorial Birds are exposed to great reductions of temperature, and for this reason the plumage is very dense, and is always kept well oiled, so as to keep the wet out.

As good examples of the Natatorial Birds may be taken the Penguins and Auks, the Gulls and Petrels, the Pelicans and Cormorants, and the Ducks, Swans, and Geese.

ORDER II. GRALLATORES.—The Wading Birds mostly spend their time wading about in shallow water, feeding upon small fishes, shell-fish, worms, and insects. Many, however, live chiefly upon the dry land, and are more or less exclusively vegetable feeders. They are distinguished by the great length of the legs, which are also unfeathered—as far, at any rate, as the lower end of the tibia. The foot has three toes in front and

usually one behind, but the toes are never completely webbed. The wings are long and the power of flight considerable, but the tail is short, and its function as a rudder is chiefly transferred to the long legs, which are stretched out behind in flight. The bill is almost always of considerable length, and is usually more or less pointed.



Fig. 102.—Penguin (*Spheniscus demersus*).

As good examples of the Grallatorial Birds may be taken the Rails, Water-hens, and Coots, the Cranes, Herons (fig. 103), and Storks, the Snipes, Sandpipers, and Curlews, and the Plovers and Bustards.

ORDER III. CURSORES.—The Running or Cursorial Birds, comprising the Ostrich, Cassowary, Emeu, Rhea, and Apteryx, are characterised by the rudimentary condition of the wings, which are useless as organs of flight, and by the compensating length and strength of the legs. In accordance with this con-

dition of the limbs, the bones have few air-cells, and the breast-bone is destitute of the prominent ridge or keel, to which the muscles of flight are attached in the birds which fly. The legs are extremely powerful, and the hinder toe is wanting in all



Fig. 103.—Common Heron (*Ardea cinerea*).

except the *Apteryx* (fig. 104), in which it is present in a rudimentary condition. The front toes are either two or three in number, and are furnished with strong blunt claws. The feathers are peculiar in the fact that the barbs are separate, and are not united to one another by the barbules.

The African Ostrich (*Struthio camelus*) inhabits the desert plains of Africa and Arabia, and is the largest of living birds, attaining a height of from six to eight feet. The feet have only two toes each, but the legs are extremely powerful, and the Ostrich can run with extraordinary speed. The American Ostriches or Rheas are much smaller than the true Ostriches, and the feet have three toes each. They inhabit tropical America. The Emeu is exclusively confined to New Holland, and nearly equals the Ostrich in height. The Cassowary inhabits the Moluccan Islands and New Guinea, and was first

brought alive to Europe by the Dutch. The *Apteryx*, the last of the living Cursorial Birds, is a native of New Zealand, and is remarkable in having the nostrils placed at the very extremity of the upper mandible of the bill.



Fig. 104.—The *Apteryx Australis* (Gould).

ORDER IV. RASORES.—The Scratching Birds—or, as they are often called, the Gallinaceous Birds—are characterised by having the upper mandible of the bill convex, and having a membranous space at its base in which the nostrils are pierced. The nostrils are also defended by a cartilaginous scale. The feet have four toes each, three in front and a short hind toe ; and in the typical forms the toes are provided with strong blunt claws suitable for scratching. The feet of the Pigeons, however, are generally adapted for perching.

The Rasorial Birds are divided into two very well marked groups. In the first of these are the Fowls, Pheasants, Grouse, Guinea-fowl, Turkey, Pea-fowl, and other allied birds. In the second group are the Pigeons and Doves (fig. 105), distinguished by the fact that the feet are slender, and adapted for perching, whilst the voice is of a gentle, soft, and melancholy character.

ORDER V. SCANSORES.—The Climbing Birds are distinguished by the fact that the feet have four toes each, of which two are turned backwards and two forwards. This arrangement of the toes enables the Scansorial Birds to climb with great ease and readiness.

The most important families of the *Scansores* are the Cuckoos (*Cuculidæ*), the Woodpeckers (*Picidæ*), and the Parrots,



Fig. 105.—Rock-pigeon (*Columba livia*).

Parrakeets, Love-birds, Lories (fig. 106), and Macaws (*Psittacidae*). Many of the Cuckoos have the remarkable instinct of laying their eggs in the nests of other birds. The Parrots are all natives of hot climates, and the beak is hooked, and is used as a kind of third foot in climbing.

ORDER VI. INSESSORES.—The Perching Birds are chiefly distinguished by the characters of the feet. These are chiefly adapted for building the nest and for perching on trees, and "have neither the webbed structure of those of the *Swimmers*

nor the robust strength and destructive talons which characterise the feet of the *Birds of Rapine*, nor yet the extended toes which enable the *Wader* to walk safely over marshy soils and tread lightly on the floating leaves of aquatic plants; but the toes are slender, flexible, and moderately elongated, with long, pointed, and slightly curved claws" (Owen). The feet have



Fig. 106.—Purple-capped Lory (*Lorius domicella*).

four toes each, three in front and one behind (fig. 107, A, B), and the form of the beak varies much in different sections of the order. The leading modifications in the shape of the bill are shown in the subjoined cut.

The order *Insessores* is by far the most numerous of the divisions of Birds; and it is impossible here either to discuss the characters of its leading subdivisions, or to enter into any consideration of its typical members. As good examples of the order may be taken the Crows, Jays, and Magpies (*Corvidæ*),

the Finches and Linnets (*Fringillidæ*), the Shrikes (*Laniidæ*), the Thrushes (*Merulidæ*), the Humming-birds (*Trochilidæ*), the

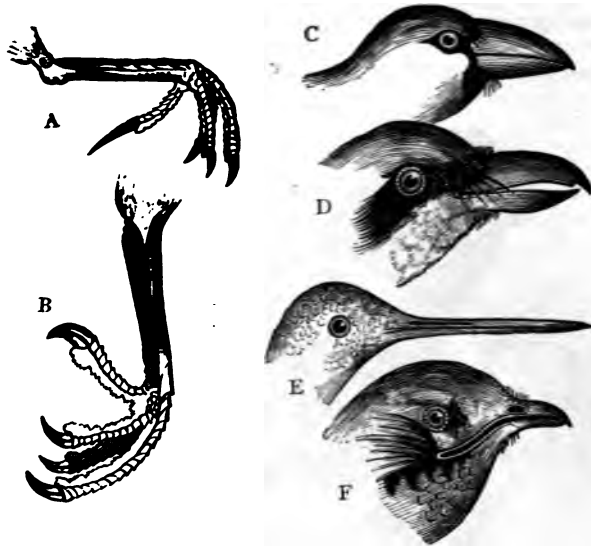


Fig. 107.—A, Foot of Yellow Wagtail; B, Foot of Water-ousel; C, Beak of Hawfinch; D, Beak of Shrike; E, Beak of Humming-bird; F, Beak of Swift.

Swallows and Martins (*Hirundinidæ*), and the Swifts (*Cypselidæ*).

ORDER VII. RAPTORES.—The Birds of Prey are character-



Fig. 108.—A, Foot of Peregrine Falcon; B, Head of Buzzard.

ised by the form of the beak, which is adapted for tearing ani-

mal food. The upper mandible of the bill (fig. 108, B) is "strong, curved, sharp-edged, and sharp-pointed, often armed with a lateral tooth" (Owen). The body is extremely muscular; the legs are robust, usually short, with three toes in front and one behind; all the toes armed with strong, curved, crooked claws or talons (fig. 108, A). All the Raptorial Birds live upon the flesh of other animals, which they either kill for themselves or find dead, and their flight is generally extremely rapid and powerful.

The Birds of Prey are divided into the two sections of the Nocturnal Birds of Prey which hunt by night, and the Diurnal Birds of Prey which hunt by day. In the former section (fig. 109) is only the single family of the Owls, in which the eyes

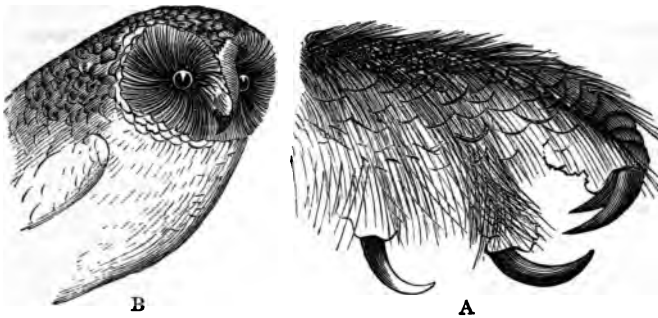


Fig. 109.—A, Foot of Tawny Owl; B, Head of White Owl.

are large and are directed forwards; whilst the plumage is exceedingly soft and loose, so as to render the flight almost noiseless. In the section of the Diurnal Raptores (fig. 108) are the Falcons and Hawks, the Eagles and the Vultures. In all these the eyes are smaller than in the Owls, and are placed on the sides of the head; and the plumage is not soft. They have long pointed wings, and mostly possess extraordinary powers of flight.

CHAPTER XXIII.

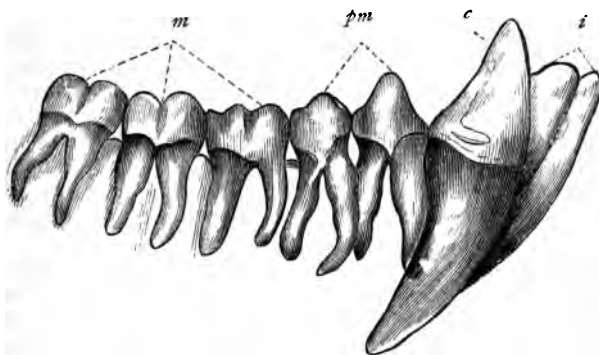
CLASS V. MAMMALIA.

THE class *Mammalia* includes all the ordinary Quadrupeds, and may be shortly defined as comprising Vertebrate animals, in which some part or other of the skin is always furnished with hairs, and the young are nourished for a longer or shorter time by means of a special fluid—the milk,—secreted by special glands belonging to the mother—the mammary glands. The Mammals are farther distinguished from Birds and Reptiles by the fact that the skull is jointed to the spinal column by two joints (condyles); the lower jaw is composed of two halves, each consisting of a single piece; the blood-corpuscles (fig. 81, *a*) are generally circular, and most of them have no central particle or nucleus; the cavities of the chest (thorax) and belly (abdomen) are separated by a muscular partition, called the midriff or diaphragm; and the lungs never communicate with air-sacs placed in different parts of the body.

With regard to the structure of the skeleton in Mammals, it is only necessary to add to what was said in speaking of the *Vertebrata* generally, a few words as to structure of the limbs. The regular number of limbs in the Mammals is four, two anterior and two posterior; and for this reason they are often spoken of as Quadrupeds, regardless of the fact that in some Mammals (such as the Whales and Dolphins) only the fore limbs are present. The fore and hind limbs in all Mammals have essentially the same structure as described in treating of Vertebrates generally (p. 114, 115). The shoulder-blade or *scapula* is never absent, and the *coracoid bones*, which form such a marked feature in the shoulder-girdle of Birds, are with hardly an exception amalgamated with the scapulæ. The *clavicles* or collar-bones are often wanting or rudimentary, but in no Mammal are they ever united together in front so as to form a "furculum" or "mermaid-bone." The regular number of fingers or digits in the fore limb, as of toes in the hind limb, is

five; but they vary from one to five, the middle finger being the longest and most persistent, and being the only finger left in the living Horses. Properly, each finger consists of three short bones or *phalanges*, except the thumb, which has two; but this rule is occasionally departed from.

The great majority of Mammals possess *teeth*, but these are wanting in the fully-grown whalebone Whales and in the Scaly and Great Ant-eaters. The teeth, also, are almost invariably implanted in distinct and separate sockets in the jaw. Some Mammals have only a single set of teeth; but in most cases the young Mammal possesses a set of what are called *milk-teeth*, which is ultimately replaced by a second set, constituting the *permanent* teeth. No Mammal has ever *more* than two set of teeth. In Man, and in many other Mammals, the teeth are divisible into four groups, which differ from one another in position, appearance, and function, and which are termed respectively the *incisors*, *canines*, *præmolars*, and *molars*. It is impossible



110.—Teeth of the right side of the lower jaw of the Chimpanzee (after Owen).
i Incisors; *c* Canine tooth; *pm* Præmolars; *m* Molars.

to describe fully which teeth come under each of these heads without entering into minute details as to the structure of the jaws. It will be sufficient here to point out the general characters and position of these groups in a good illustrative example, such as one of the higher Apes (fig. 110). The *incisor* teeth (*i*) vary greatly in size and number, but they are always placed in the front of the mouth, and are the teeth which are used in simply biting or dividing the food. The *canine* or eye-tooth (*c*) is generally longer or more pointed than the other

teeth. The canines are sometimes wanting, or are sometimes present in one jaw and not in the other, but there are never more than four altogether—that is to say, one on each side of each jaw. The præmolars (*pm*) and the molars (*m*) are generally known as the “back teeth” or “grinders,” and they vary a good deal in number and function, being sometimes adapted for cutting the food, but more usually for chewing and grinding it down.

The skin is almost invariably furnished over a greater or less part of its surface with appendages which are known as *hairs*, and which differ from feathers chiefly in not splitting up as they are produced. Sometimes the hairs form scales, as in the Scaly Ant-eater, and they are often developed into long spines or prickles, as in the Hedgehogs and Porcupines. In the Whales the body is almost hairless, and in the Dolphins quite so; but these latter have hairs upon the muzzle before they are born.

The young Mammal is always born in a helpless condition, and is nourished for a longer or shorter time by means of the milk of the mother. The milk is secreted by special organs called the “mammary glands,” and it is from the presence of these that the name *Mammalia* is derived (Lat. *mamma*, the breast). The number and position of the mammary glands vary in different cases, but they always are placed on the lower surface of the body, and their ducts almost always open upon a special eminence called the teat or nipple. In one or two cases, however, there are no nipples, and the mammary glands open by simple slits in the skin of the abdomen.

In the great majority of Mammals the young animal is nourished within the body of the mother by an organ which is composed of a network of blood-vessels, and is called the *placenta*. In two orders of Mammals, however, the young are born at a very early period of their existence, before there is any necessity for the formation of a placenta. From this difference the class *Mammalia* is divided into the two great divisions of the Placental and Aplacental Mammals, and these contain the following fourteen orders :—

DIVISION A.—APLACENTAL MAMMALS.

Order 1.—*Monotremata*.

Order 2.—*Marsupialia*.

DIVISION B.—PLACENTAL MAMMALS.

Order 3.—*Edentata*.

Order 4.—*Sirenia*.

- Order 5.—*Cetacea*.
- Order 6.—*Ungulata*.
- Order 7.—*Hyracoidea*.
- Order 8.—*Proboscidea*.
- Order 9.—*Carnivora*.
- Order 10.—*Rodentia*.
- Order 11.—*Cheiroptera*.
- Order 12.—*Insectivora*.
- Order 13.—*Quadrumana*.
- Order 14.—*Bimana*.

CHAPTER XXIV.

ORDERS OF MAMMALS.

ORDER I. MONOTREMATA.—The first and lowest order of the Mammals, that of the *Monotremata*, comprises only the Duck-mole and Porcupine Ant-eater, both of which are exclusively confined to New Holland. Irrespective of some remarkable peculiarities in their internal anatomy, the Monotremes are distinguished by having no true teeth, by possessing distinct “coracoid bones” in the shoulder-girdle, like those of Birds, and by having the so-called “marsupial bones.” These last are two little bones attached to the front of the bony arch (pelvic arch) by which the hind limbs are attached to the trunk. They possess, however, no “marsupial pouch,” as occurs in the next order. They have, further, no external ears, and no nipples to the mammary glands, and the young are said to be destitute of a placenta.

The Duck-mole (*Ornithorhynchus*) is an extraordinary Mammal, which inhabits the rivers and lakes of Australia and Tas-



Fig. 111.—Duck-mole (*Ornithorhynchus*)—after Waterhouse.

mania. The body (fig. 111) is like that of a small otter, and is covered with a short brown fur. The tail is broad and flattened, and the jaws are sheathed with horn, so as to form a flattened beak, very like that of a duck. There are no true teeth, but

the bill is furnished with small horny plates which act as teeth. The legs are short, furnished with five toes each, and webbed, so that the animal swims with great ease. Their food consists chiefly of aquatic insects and molluscs, and they make very extensive burrows in the banks of streams.

The Porcupine Ant-eater (*Echidna*) is not at all unlike a hedgehog in appearance, but larger. The skin is covered with bristly hair, with strong prickly spines on the back. The snout is very long, and there are no teeth, but the jaws are encased in skin to close upon the end of the snout, where there is a small aperture for the protrusion of a long and flexible tongue. The feet are adapted for digging and burrowing, and the animal feeds upon insects, which it captures by means of its long sticky tongue.

ORDER II. MARSUPIALIA.—The name *Marsupialia* is derived from the fact that the females of this order have a pouch or fold of the skin of the abdomen, which is termed the *marsupium*



Fig. 112.—The Koala or Kangaroo-bear (*Phascogale cinerea*)—after Gould.

and within which the nipples are placed. The young are born in a very immature and helpless condition, and are placed in this pouch by the mother, where they remain until able to take care of themselves. The so-called "marsupial bones" are

present, as in the *Monotremata*, but the "coracoid bones" are amalgamated with the shoulder-blades, and true teeth are always present.

As regards their geographical distribution, with the single exception of the various Opossums (*Didelphys*) of America, the whole order of the Marsupials is exclusively confined to Australia, Tasmania, New Guinea, and the adjacent islands. As good examples of the Marsupials we may take the Kangaroos, the Kangaroo-bear, and the Native Devil of Van Diemen's Land. The Kangaroos (*Macropus*) are vegetable feeders, and are distinguished by the great disproportion between the fore and hind legs, the latter being by far the longest and strongest. By their long hind legs, assisted by a powerful tail, the Kangaroos can take astonishing jumps, and leaping is their ordinary mode of progression when pursued. The Kangaroo-bear or Koala (fig. 112), like the Kangaroos, is a vegetable feeder, and is a sluggish harmless animal. By the structure of the feet it is admirably adapted for climbing amongst the trees, upon the foliage of which it feeds. It is covered with a close greyish fur, and the ears are furnished with long tufts of hair. The Native Devil (*Dasyurus ursinus*) is a good example of those Marsupials which live upon animal food, or are carnivorous. It is furnished with long and strong canines, and with other teeth adapted for cutting flesh, and it is a destructive and ferocious animal. Though only as big as a small dog, it commits great havoc amongst the flocks of Van Diemen's Land, and has, in return, been to a great extent hunted down by the settlers of that island.

ORDER III. EDENTATA.—The members of this order, the Sloths, Armadillos, and Ant-eaters, are characterised by the fact that the teeth are not covered by enamel, have no complete roots, and are not succeeded by a second set. In none are there any central incisors, and in all but one there are no incisors at all. In two genera there are no teeth at all, and to these the name *Edentata* would be strictly applicable. In all, the toes are furnished with long and powerful claws.

The Sloths (*Bradypodidæ*) are exclusively confined to South America, inhabiting the vast and trackless forests of this continent. They are admirably adapted for their mode of life, which necessitates their living almost exclusively amongst and upon the trees, on the leaves of which they feed. They are, however, extremely awkward upon the ground, as their long curved claws are intended to allow them to move about, back downwards, amongst the branches of trees.

The Armadillos (*Dasypodidae*) are also exclusively confined to South America, but they are carnivorous burrowing animals,

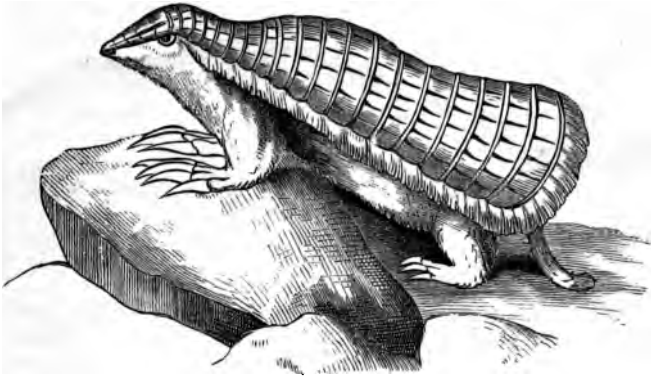


Fig. 113.—Armadillo (*Chlamyphorus*).

and are furnished with strong digging claws. The upper surface of the body (fig. 113) is protected by a kind of armour formed of hard bony plates or shields united at their edges. Most of them can roll themselves into a ball, like the Hedgehog, and they can all bury themselves in the ground if pursued.

Besides the Sloths and Armadillos, South America can boast of possessing the hairy Ant-eaters, of which the best known is the great Ant-eater (*Myrmecophaga jubata*). The body in this curious animal is hairy, with a long bushy tail; and teeth are wholly absent. It lives upon insects, which it catches by rapidly protruding and retracting its long and sticky tongue.

The Old World possesses only two genera of *Edentata*, comprising the scaly Ant-eaters (*Manis*) of Asia and Africa, and the Ground Hog (*Orycteropus*) of South Africa. The scaly Ant-eaters or Pangolins are remarkable for having the body covered with a flexible armour composed of horny plates or scales, overlapping like the tiles of a house.

ORDER IV. SIRENIA.—This order comprises only the great sea-animals known as Dugongs and Manatees. They were long classed with the Whales and Dolphins, and agree with them in being adapted to a thoroughly aquatic life, having no hind limbs, but having the fore limbs converted into swimming-paddles, whilst the hinder end of the body (fig. 114) forms a

powerful horizontal tail-fin. They differ from the Whales and Dolphins in having the nostrils placed at the front of the head, and in having molar teeth with flat crowns adapted for a vegetable diet.

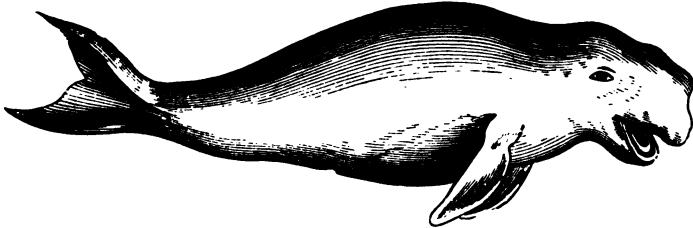


Fig. 114.—The Dugong (*Halicore Indicus*).

The Manatees, or, as they are often called, “Sea-cows,” are found on the east coast of America and the west coast of Africa, and are large awkward animals, attaining a length of from eight to ten or fifteen feet. They are vegetable-eaters, feeding chiefly upon sea-weeds, and haunting the mouths of rivers and estuaries. The Dugongs (fig. 114) differ little in appearance and habits from the Manatees, and are found on the coasts of the Indian Ocean and the north coast of Australia. They attain a length of from eighteen to twenty feet, and are often killed and eaten.

ORDER V. CETACEA.—This order includes the Whales, Dolphins, and Porpoises, and agrees with the *Sirenia* in the fact that its members are adapted to a completely aquatic life. The body is fish-like in form (fig. 115), the hind-limbs are wanting,

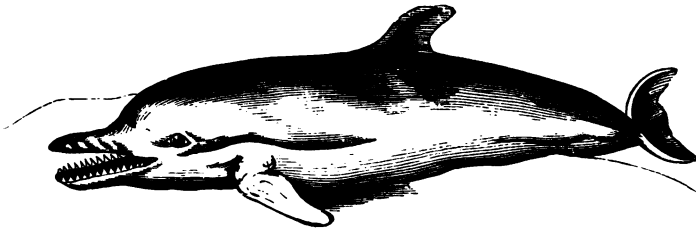


Fig. 115.—The common Dolphin (*Delphinus delphis*).

and the fore limbs are converted into swimming-paddles or “flippers,” whilst the hinder end of the body forms a very

powerful horizontal tail-fin. The nostrils form a single or double aperture, which is placed on the top of the head and is known as the "blow-hole." The body is very sparingly furnished with hairs, or is quite hairless. The head is disproportionately large, and the adult has either no teeth at all or possesses a single set of conical teeth not separable into distinct groups. They are all carnivorous or live upon animal food.

The most important of the *Cetacea* are the whalebone Whales (*Balenida*), in which the adult has no teeth, but the palate is furnished with a number of transverse plates of whalebone or *baleen*. These baleen-plates have their edges furnished with numerous fibres of whalebone, and the whole apparatus is used as a kind of sieve or filter to separate from the sea-water the minute marine animals upon which these enormous creatures feed. The best known and most valuable of the whalebone Whales is the Greenland Whale, which yields most of the whale-oil and whalebone of commerce. It is a native of the Arctic seas, and attains a length of from forty to sixty feet. The oil is derived from a thick layer of fat or "blubber," which is situated immediately under the skin. The discovery of a whale is usually made by means of what is called the "spouting" or "blowing" of the animal. This consists in the forcible ejection from the blow-hole of a column or jet of watery vapour, mixed with water, which is visible for a considerable distance.

The Toothed Whales are best known by the Sperm Whale, an animal as large or larger than the Greenland Whale, but distinguished by having numerous conical teeth, a single blow-hole, and a curiously-truncated head. The Sperm Whales yield an excellent oil, and also the singular fatty substance known as spermaceti.

The Dolphins and Porpoises form the last family of the *Cetacea*, and are distinguished by their single blow-hole and numerous conical teeth. They are inhabitants of the sea, but two species of Dolphin live in rivers—one in America, and the other in India. One of the most remarkable of this group is the Narwhal or Sea-unicorn, which inhabits the Arctic seas. In this singular animal one of the incisor teeth of the males is enormously developed, and constitutes a great tusk or pole of ivory, eight or ten feet in length, and having its whole surface spirally twisted.

ORDER VI. UNGULATA.—This order comprises the so-called Hoofed Quadrupeds, and is characterised by having all the four limbs, and by having that portion of the toe which touches the

ground encased in a greatly expanded nail or *hoof*. There are never more than four full-sized toes to each foot, and the legs are only used in locomotion and in supporting the weight of the body. There are always two sets of teeth, and the molars have broad crowns adapted for grinding vegetable substances.

The *Ungulates* are divided into two great sections, according as the toes are even or odd in number:—

A. Perissodactyla, or Odd-toed Ungulates, in which the toes are odd in number—either one or three; and if horns are present they are not in pairs.

B. Artiodactyla, or Even-toed Ungulates, in which the toes are even in number—either two or four; and if horns are present they are in pairs.

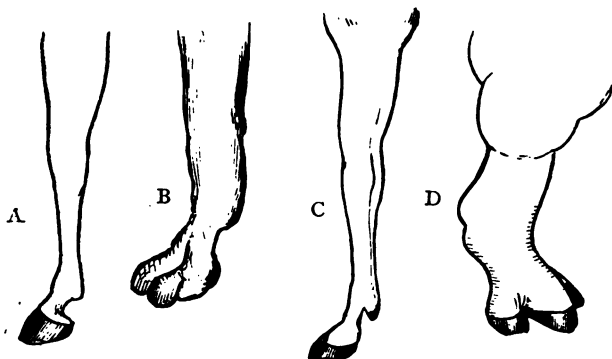


Fig. 116.—Feet of *Ungulata*. A, Odd-toed foot of Zebra; B, Even-toed foot of Llama; C, Even-toed foot of Antelope; D, Odd-toed foot of Rhinceros.

The living *Perissodactyle* or *Odd-toed Ungulates* are the *Rhinoceros*, the *Tapirs*, and the *Horse* and its allies. The *Rhinoceroses* are extremely large and bulky brutes, having a thick and nearly hairless skin, usually thrown into deep folds. The feet (fig. 116, D) are furnished with three toes each, all encased in hoofs. The nose is furnished with one or two horns composed of longitudinal fibres, and without any central core of bone. When two horns are present (fig. 117) they are not *paired*, but one is always placed behind the other in the middle line of the body, and the hinder one is much the shorter. The various species of *Rhinoceros* are found in Java, Sumatra, India, and Africa, inhabiting marshy places, and feeding chiefly upon the foliage of trees.

The *Tapirs* are large clumsy animals, which inhabit South America, Sumatra, and Malacca. They have the nose prolonged into a short movable proboscis or trunk, which they employ in stripping off the leaves of trees.

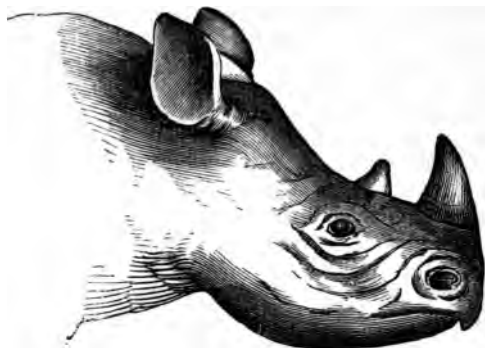


Fig. 117.—Head of two-horned Rhinoceros.

The last family of the Perissodactyle Ungulates is that of the *Equidæ*, comprising the Horse, Ass, Zebra, and Quagga. In this family the toes are reduced to *one* to each foot, enclosed in a single broad hoof, without any supplementary hoofs (fig. 116, A). At the present day all the members of the family *Equidæ* are natives of the Old World, but fossil horses occur in both North and South America, and the horse has now become completely naturalised in the New World.

The *Artiodactyla*, or Even-toed Ungulates, are divided into two groups :—

1. *Omnivora*, as the Pig and Hippopotamus.
2. *Ruminantia*, which **chew** the cud, such as Oxen, Deer, Camels, &c.

Of the *Omnivorous* forms, the Hippopotamus is characterised by its massive heavy body, short blunt muzzle, and feet with four hoofed toes each. The Hippopotamus is found in Africa, and reaches a length of eleven to twelve feet. It is nocturnal in its habits, and swims and dives with great facility. The Pigs, Peccaries, and Wart-hogs have usually four toes to each foot, but only two support the weight of the body, the remaining toes being placed at some elevation on the back of the foot. They have a short movable snout, and the tail is very short, or is represented by a mere tubercle.

The *Ruminants* are distinguished by their "cloven" feet, each consisting of two symmetrical hoofed toes, looking as if produced by the splitting into two of a single hoof. Often there are also two small supplementary toes placed on the back of the foot. As a general rule, the Ruminants have neither canine nor incisor teeth in the upper jaw, and the lower incisors bite against a hardened pad of gum. There are six præmolar and molar teeth on each side of each jaw, and these have grinding surfaces. The stomach is divided into several compartments, and all the Ruminants "chew the cud" or "ruminate"—that is to say, they first swallow their food unmasticated, and then bring it up again after a longer or shorter period in order to chew it.

The most important families of the *Ruminantia* are the Camels and Llamas (*Camelidæ*), the true Deer (*Cervidæ*), the Giraffes, and the Oxen, Sheep, Goats, and Antelopes (*Cavicornia*).

The Camels and Llamas have no horns—and the feet have two toes, each covered by imperfect nail-like hoofs. The true



Fig. 118.—Head of Stag (*Cervus elaphus*).

Camels are exclusively confined to the Old World, and their place is taken in South America by the Llama and Alpaca.

The family *Cervidæ* includes the true Deer, and is characterised by the fact that the forehead carries two solid bony "antlers," which are not hollow, and are generally much branched. With the single exception of the Reindeer, these appendages are confined to the males, and they are annually produced and annually shed, increasing in size and in the number of branches every time they are reproduced. They must be carefully distinguished from the *hollow* horns of Antelopes, Oxen, Sheep, and the like.

The Giraffe is exclusively confined to the African continent, and only a single species is known. Both sexes have a pair of short horns, but these are persistent, and are covered with a hairy skin. The neck is extremely long, and the fore legs longer than the hind legs. It is the largest of living Ruminants, and attains a height of from fifteen to eighteen feet.

The *Cavicornia*, or *Hollow-horned* Ruminants, are characterised by having *hollow* horns, consisting of an outer sheath of horn surrounding a central bony stem or "horn-core" (fig. 119).



Fig. 119.—Head of an Antelope, the Koodoo (*Strepsiceros koodoo*).

The horns are persistent, and are not periodically shed; and there is usually only a single pair, though sometimes there are two pairs. The group of the *Cavicornia* comprises the Oxen, Sheep, Goats, and Antelopes, and may be regarded as the most typical section of the Ruminants.

ORDER VII. HYRACOIDEA.—This order merely requires to be mentioned, as it includes only a single genus (*Hyrax*), of which just two or three species are known. They are all gregarious

little animals, living in holes of the rocks, and capable of domestication. One species occurs in South Africa, and is known to the Dutch colonists as the "Badger." Another species occurs in the rocky parts of Arabia and Palestine, and is believed to be the animal referred to in Scripture as the "Coney."

ORDER VIII. PROBOSCIDEA.—This order is represented at the present day by the Elephants only, of which no more than two species are known. One of these is the African Elephant, distinguished by its convex forehead and great flapping ears; the other is the Indian Elephant, which has a concave forehead and small ears. The name *Proboscidea* is derived from the fact that the nose is prolonged into a long cylindrical trunk or *proboscis* (fig. 120, *n*), at the extremity of which the nostrils are

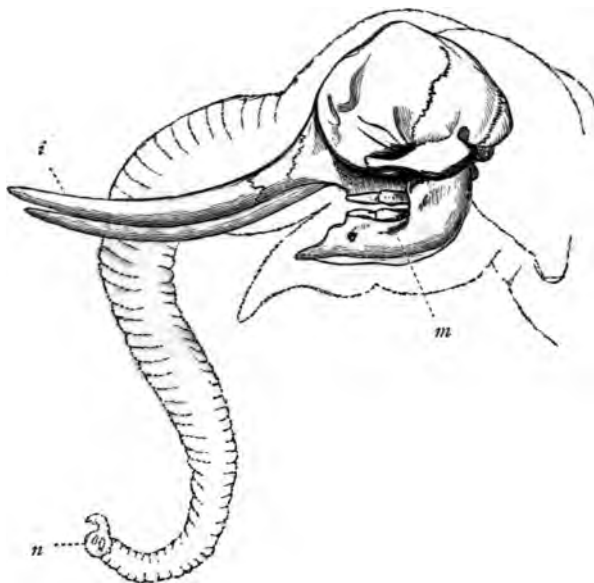


Fig. 120.—Skull of the Indian Elephant. *i* Tusk-like upper incisors; *m* Lower jaw, with grinding molars, but without incisors; *n* Nostrils, placed at the extremity of the proboscis.

placed. There are no canine teeth, nor lower incisors, and the molar teeth are few in number and of large size. The upper

incisors, however, are two in number, continue growing during the life of the animal, and constitute the well-known "tusks" of the Elephant (fig. 120, *i*). The feet are furnished with five toes each, but these are only imperfectly indicated externally by the divisions of the hoof; and the animal walks upon thick pads of integument which constitute the soles of the feet.

Though only two living Elephants are known, many fossil forms have been detected; and one of these, the Mammoth, is believed to have survived into the human period.

ORDER IX. CARNIVORA.—The Carnivorous Mammals or Beasts of Prey are chiefly distinguished by the adaptation of their teeth to an animal diet. The incisor teeth are generally six in each jaw; the canines are two in each jaw, and are always long and pointed. The molars and præmolars are mostly furnished with sharp cutting edges, adapted for dividing flesh; but one or more of the hinder molars is generally furnished with a simply tuberculate crown, adapted for bruising rather than cutting. The feet in the *Carnivora* are always furnished with strong curved claws, and the collar-bones are quite rudimentary, or are altogether wanting. The *Carnivora* are divided into the following three sections, founded upon the nature of the limbs:—

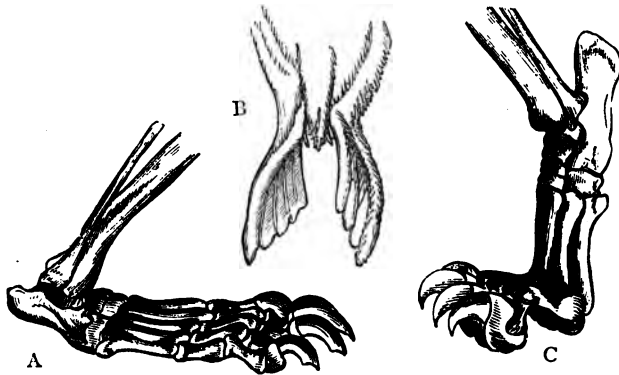


Fig. 121.—Feet of *Carnivora* (after Owen). A, *Plantigrada*; Foot of Bear. B, *Pinnigrada*; Hind feet of Seal. C, *Digitigrada*; Foot of Lion.

1. *Pinnigrada* (fig. 121, B) in which both the fore and hind legs are short, and the feet form broad webbed swimming-paddles. The hind feet are placed very far back, nearly in a line with the

axis of the body. This section comprises the Seals and Walruses, characterised by their adaptation to an aquatic mode of life. They are, however, at once distinguished from the *Sirenia* and *Cetacea* by possessing well-developed *hind limbs*. The Seals form a very numerous family, of which species are found in most seas out of the tropics. They are largely captured both for their oil and fur; and the subjoined cut will give an idea of most of their external peculiarities.

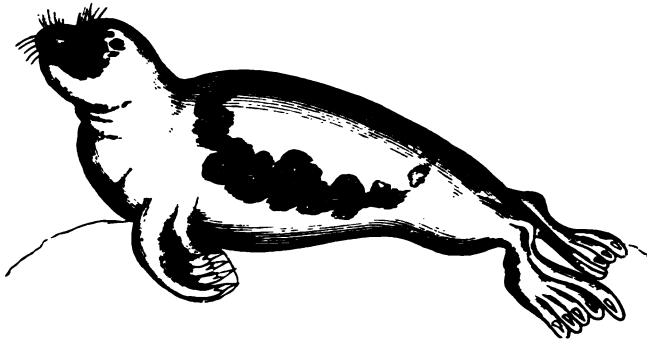


Fig. 122.—Greenland Seal (*Phoca Grœnlandica*).

The Walrus or Morse is like the Seals in most respects, but the upper canine teeth are developed into two large pointed tusks. It is a large heavy animal which is found in flocks in the Arctic seas, and is hunted both for its blubber and for the ivory of its tusks.

2. *Plantigrada* (fig. 121, A), in which the whole or nearly the whole of the foot is applied to the ground, so that the animal walks upon the soles of the feet. The most characteristic members of this order are the Bears (*Ursidæ*), of which the common Brown Bear and the White or Polar Bear are familiar examples. The Bears eat flesh when they can get it, but they are very miscellaneous in their diet, and their teeth do not, therefore, exhibit the typical carnivorous characters, the præmolars and molars having broad tuberculate crowns. The claws are large, curved, and strong, but are not retractile, and the tongue is smooth.

3. *Digitigrada* (fig. 121, C), in which the heel is raised from the ground, and the animal walks upon tiptoe. The most typical members of this section are the Dogs (*Canidæ*), the

Hyænas (*Hyænidæ*), and the Cats (*Felidæ*). Besides the true Dogs, the family *Canidæ* comprises the Wolves, Foxes, and Jackals. The Hyænas are ferocious, ill-conditioned animals, which occur in Africa, Asia Minor, Arabia, and Persia. The group of the *Felidæ*, besides the true Cats, comprises a number of the fiercest and most typical members of the whole order *Carnivora*, such as the Lion, Tiger, Leopard, Jaguar, Puma, and Lynx. They are all characterised by the completely carnivorous form of their teeth, the possession of strong curved claws which can be withdrawn within sheaths by the action of elastic ligaments, and by the fact that the tongue is rough and prickly.

ORDER X. RODENTIA.—In this order are a number of small animals, characterised by having no canine teeth, but by having two long curved incisors in each jaw, separated by an interval from the molars (fig. 123, A). Sometimes there are four inci-

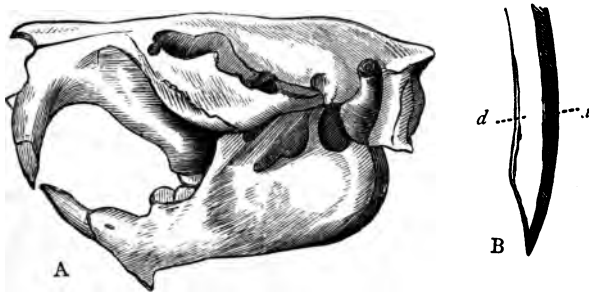


Fig. 123.—A, Skull of the Beaver. B, Diagram of one of the incisor teeth of a Rodent: *a* Enamel; *d* Soft tooth substance.

sors in the upper jaw, but there are never more than two in the lower. Each incisor (fig. 123, B) is long and curved, and continues growing during the life of the animal. The front of the tooth is covered with a layer of hard enamel, and the softer parts of the tooth are placed behind. The result of this is, that as the tooth is used in gnawing, the softer parts of the tooth behind wear away more rapidly than the hard enamel in front, and thus the crown of the tooth assumes by use a chisel-shaped point, which has a sharp cutting edge formed by the enamel. From this structure of the incisors, the Rodents are adapted for rapid and continuous gnawing, and they live chiefly upon the harder parts of plants, such as the bark and roots. The Rodents

are almost all of small size, and are very generally distributed over the whole world. The most important families included in



Fig. 124.—The Hamster (*Cricetus vulgaris*).

the order are the Hares and Rabbits (*Leporidae*), the Capybaras and Guinea-pigs (*Cavidae*), the Beavers (*Castoridae*), the Rats



Fig. 125.—Skeleton of a Bat (*Pteropus*)—after Owen.

and Mice (*Muridae*), the Porcupines (*Hystriidae*), the Dormice (*Myoxidae*), and the Squirrels and Marmots (*Sciuridae*).

ORDER XI. CHEIROPTERA.—This order comprises only the Bats or Flying Mammals, characterised by the fact that the fore limbs are much longer than the hind limbs, and have several of the fingers greatly lengthened. These immensely-lengthened fingers are united by an expanded leathery membrane, which not only stretches between the fingers, but is also extended between the fore and hind limbs, and is attached to the sides of the body (fig. 125). The flying-membrane often stretches between the hind legs and includes the tail, and it is nearly or quite hairless. By means of this flying-membrane the Bats enjoy the power of true flight, and they are the only Mammals which do so, though their flight is by no means so rapid and active as in the true Birds.

The Bats are all twilight-loving or nocturnal animals, and are divided into two sections, according as they live upon insects or feed chiefly upon fruits. In the first section are all our British Bats. In the second section are the so-called Fox-bats (*Pteropidae*), which are especially characteristic of the Pacific Archipelago, and sometimes attain a very large size, one species having a stretch of wing of from four to five feet.

ORDER XII. INSECTIVORA.—This order includes a number of small animals, which in many respects are very like the Rodents, but have not the peculiar incisor teeth of that order. All the three kinds of teeth are present, and the molar teeth are

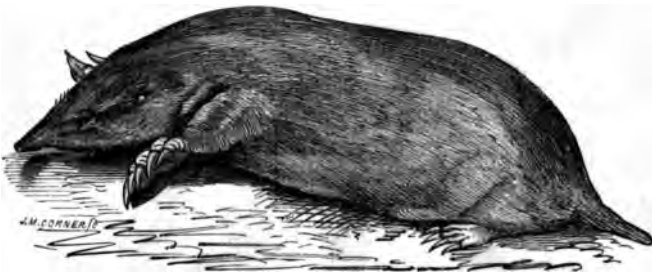


Fig. 126.—The Mole (*Talpa Europæa*).

distinguished by having small pointed eminences or "cusps," adapted for crushing insects. Collar-bones are always present, and most of the *Insectivora* are *plantigrade*—that is to say, they walk upon the soles of the feet. They are all of small size, and

they exist over the whole world, except in Australia and South America, where their place is taken by small Marsupials, such as the Opossums.

The three most important families of the *Insectivora* are the Moles (*Talpidae*), the Shrews (*Soricidae*), and the Hedgehogs (*Erinaceidae*). The Moles are all nocturnal burrowing animals, and the feet have strong curved digging claws. The eyes are completely rudimentary in the adult, and sight must be almost altogether wanting. The Shrews are very like the true Mice in external appearance, but are really widely different. They are very widely distributed, and one of them is probably the smallest of existing Mammals. The Hedgehogs are extremely familiar to every one, by having the upper surface of the body covered with short prickly spines, and by having the power of rolling themselves up into a ball on the approach of danger.

ORDER XIII. QUADRUMANA.—This order includes the Apes, Monkeys, Baboons, and Lemurs, and is characterised by the

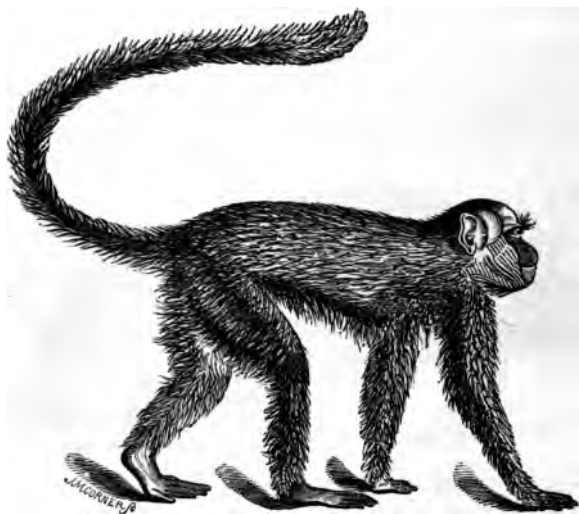


Fig. 127.—Green Monkey (*Cercopithecus sabaeus*)—after Cuvier.

fact that the innermost toe of the hind limb (great toe) can be *opposed* to the other toes, so that the hind feet become prehensile

hands. The term "opposed" simply implies that the toe can be so adjusted as regards the extremities of the other toes that any object can be grasped between them, just as the thumb of the human hand can be "opposed" to the other fingers. The fore-feet of the *Quadrumana* may be destitute of a thumb, but when this is present it is generally opposable to the other digits, so that the animal becomes truly four-handed or "quadrumanous."

The most important group of the lower *Quadrumana* is that of the Lemurs, comprising a number of small cat-like animals, with a close soft fur and long hairy tails. The Lemurs are often called "Madagascar Cats," and are exclusively confined to the large forests of that island, moving about amongst the trees with great activity by means of their prehensile tails. The South American Monkeys, such as the Marmosets, Howlers, and Spider-monkeys, live amongst the great forests of that continent, and are mostly adapted for climbing about amongst trees. Their tails are therefore generally prehensile, and the thumbs of the fore feet are either wanting or are not opposable to the other fingers.

The highest Apes are those which inhabit the Old World, and they are distinguished by never having a prehensile tail, whilst the thumbs of the fore feet are opposable. Amongst these are the *Macques* and *Semnopithec*i of Asia, and the hideous Baboons of Africa. The highest of the Old World Apes are often called *Anthropoid*, from their making a closer approach to man in anatomical structure than is the case with any other Mammal. The Anthropoid Apes have neither tails nor cheek-pouches, and the best-known members of the group are the Orang-outang, the Chimpanzee, and the Gorilla. All these Apes mimic man more or less closely in appearance and structure, but much more closely when young than when grown up. The Orang-outang inhabits Sumatra, Borneo, and the other larger islands of the Indian Archipelago. The Chimpanzee inhabits Western Africa, and the Gorilla inhabits Lower Guinea and Equatorial Africa. The latter attains a height of fully five feet, and is enormously strong and ferocious.

ORDER XIV. BIMANA.—In this order stands Man alone, and little need therefore to be said on this head. Man is distinguished *zoologically* from all other Mammals by his habitually erect posture and progression upon two legs. The lower limbs are exclusively devoted to progression and to supporting the weight of the body. The fore limbs are shorter than the legs,

and have nothing to do with progression. The thumb can be opposed to the other digits, and the hands are therefore prehensile. The fingers and toes are furnished with nails; but the great toe is not capable of being opposed to the other toes, so that the foot is useless as an organ of grasping. The foot is broad and plantigrade, the whole sole being applied to the ground in walking. The teeth form a nearly even and uninterrupted series, without any gap or interval. The brain is more largely developed and more richly furnished with large and deep foldings than is the case with any other Mammal. Lastly, Man is the only terrestrial Mammal in which the body is not furnished with a general covering of hair.

We thus see that the purely *anatomical* distinction between Man and the other Mammals are by no means so striking as might have been anticipated; but this should lead us to perceive that Man's place in nature is to be settled not by his anatomical structure, but by the perfection of his mental and moral attributes.

TABULAR VIEW OF THE CHIEF DIVISIONS OF THE VERTEBRATA.

CLASS I. PISCES (FISHES).—Respiration by gills; heart usually two-chambered; blood cold; limbs, when present, in the form of fins.

- Order 1. *Pharyngobranchii*.—*Ex.* Lancelet.
- Order 2. *Marsipobranchii*.—*Ex.* Lampreys.
- Order 3. *Teleostei*.—*Ex.* Eels, Herring, Cod.
- Order 4. *Ganoidei*.—*Ex.* Bony Pike, Sturgeon.
- Order 5. *Elasmobranchii*.—*Ex.* Sharks and Rays.
- Order 6. *Dipnoi*.—*Ex.* Mud-fish.

CLASS II. AMPHIBIA.—Respiration at first by gills, afterwards by lungs, alone or associated with gills; limbs never converted into fins; heart of the adult three-chambered.

- Order 1. *Ophiomorpha*.—*Ex.* Cæcilia.
- Order 2. *Urodela*.—*Ex.* Newts.
- Order 3. *Anoura*.—*Ex.* Frogs and Toads.

CLASS III. REPTILIA.—Respiration by lungs, and never by gills; heart three-chambered, or rarely four-chambered, its two sides always communicating with one another directly or indirectly; blood cold; integumentary covering in the form of scales or plates, and never in the form of feathers.

- Order 1. *Chelonia*.—*Ex.* Tortoises and Turtles.
- Order 2. *Ophidia*.—*Ex.* Vipers, Boas, Rattlesnakes.
- Order 3. *Lacertilia*.—*Ex.* Lizards, Blind-worm.
- Order 4. *Crocodylia*.—*Ex.* Crocodiles, Alligators.

CLASS IV. AVES (BIRDS).—Respiration by lungs ; lungs connected with air-receptacles ; blood warm ; integumentary covering in the form of feathers ; fore limbs converted into wings ; animal oviparous.

- Order 1. *Natatores*.—*Ex.* Ducks, Gulls, Penguins.
- Order 2. *Grallatores*.—*Ex.* Herons, Storks, Cranes.
- Order 3. *Cursores*.—*Ex.* Ostrich, Emeu.
- Order 4. *Rasores*.—*Ex.* Grouse, Fowl, Pigeons.
- Order 5. *Scansores*.—*Ex.* Parrots, Woodpeckers.
- Order 6. *Insessores*.—*Ex.* Crows, Finches, Swallows.
- Order 7. *Raptores*.—*Ex.* Owls, Hawks, Vultures.

CLASS V. MAMMALIA.—Respiration by lungs ; lungs not connected with air-sacs ; heart four-chambered ; blood warm ; integumentary covering in the form of hairs ; animal viviparous ; the young nourished by milk, secreted by special glands—the mammary glands.

DIVISION A. NON-PLACENTAL MAMMALS :—

- Order 1. *Monotremata*.—*Ex.* Duck-mole, Echidna.
- Order 2. *Marsupialia*.—*Ex.* Kangaroos, Opossums.

DIVISION B. PLACENTAL MAMMALS :—

- Order 3. *Edentata*.—*Ex.* Sloths, Armadillos.
- Order 4. *Sirenia*.—*Ex.* Dugongs, Manatees.
- Order 5. *Cetacea*.—*Ex.* Whales, Dolphins.
- Order 6. *Ungulata*.—*Ex.* Rhinoceros, Horse, Pig, Camel, Giraffe, Deer, Oxen, Sheep.
- Order 7. *Hyracoidea*.—*Ex.* Hyrax.
- Order 8. *Proboscidea*.—*Ex.* Elephant.
- Order 9. *Carnivora*.—*Ex.* Seals, Bears, Weasels, Dogs, Wolves, Hyænas, Lions, Tigers.
- Order 10. *Rodentia*.—*Ex.* Hares, Rabbits, Rats, Mice, Porcupine, Beaver.
- Order 11. *Cheiroptera*.—*Ex.* Bats.
- Order 12. *Insectivora*.—*Ex.* Moles, Shrew-mice, Hedgehog.
- Order 13. *Quadrumana*.—*Ex.* Lemurs, Spider-monkeys, Chimpanzee, Gorilla.
- Order 14. *Bimana*.—Man.

GLOSSARY.

ABDOMEN (Lat. *abdo*, I conceal). The posterior cavity of the body in Vertebrates and in the highest Invertebrates, containing the intestines and others of the viscera.

ABRANCHIATE (Gr. *a*, without; *brachia*, gill). Destitute of branchiæ or gills.

ACANTHOCEPHALA (Gr. *akantha*, a thorn; *kephale*, head). A class of parasitic worms in which the head is armed with spines.

ACARINA (Gr. *akari*, a mite). A division of the *Arachnida* comprising the mites and ticks.

ACTINOZOA (Gr. *aktin*, a ray; *zoon*, animal). That division of *Cælenterate* animals of which the Sea-anemones may be taken as the type.

AMBULACRA (Lat. *ambulacrum*, a place for walking). The perforated spaces or rows of plates in the shell of the Sea-urchins, through which the "tube-feet" are protruded.

AMPHIBIA (Gr. *amphi*, both; *bios*, life). The class of the Frogs, Toads, Newts, and the like, which have gills when young, but develop lungs when fully grown. Most of them, therefore, live indifferently on land or in water.

ANARTHROPODA (Gr. *a*, without; *arthros*, joint; *pous*, foot). The division of *Annulose* animals in which there are no jointed appendages.

ANNELIDA (a Gallicised form of *Annulata*, Lat. *annulus*, a ring). The Ringed worms (Leeches, Tube-worms, &c.)

ANNULOIDA (Lat. *annulus*, a ring; Gr. *eidos*, form). The sub-kingdom of the *Echinodermata* and *Scolecida*.

ANNULOSA (Lat. *annulus*, a ring). The sub-kingdom of the *Anarthropoda* and *Arthropoda*.

ANOURA (Gr. *a*, without; *oura*, tail). The tail-less Amphibians, such as the Frogs and Toads.

ANTENNÆ (Lat. *antenna*, a yard-arm). The jointed horns or feelers possessed by most Articulate animals.

ANTHROPOID (Gr. *anthropos*, man; *eidos*, form). Resembling man in anatomical structure. Applied to the highest Apes.

APTEROUS (Gr. *a*, without; *pteron*, wing). Destitute of wings.

ARACHNIDA (Gr. *arachne*, a spider). A class of Articulate animals comprising the Spiders, Scorpions, Mites, and the like.

ARTHROPODA (Gr. *arthros*, a joint; *pous*, foot). The Insects, Crustaceans, and other *Annulose* animals, in which the body is furnished with jointed appendages.

ARTICULATA (Lat. *articulus*, a little joint). *Arthropoda*.

ARTIODACTYLA (Gr. *artios*, even; *daktulos*, a finger or toe). The hoofed Quadrupeds (*Ungulata*) with an even number of toes (two or four) to each foot.

ASTEROIDEA (Gr. *aster*, star; *eidos*, form). The Star-fishes and their allies.

AVES (Lat. *avis*, a bird). The class of the Birds.

- BIMANA** (Lat. *bis*, twice; *manus*, hand). The order of *Mammalia* constituted by Man alone.
- BRACHIOPODA** (Gr. *brachion*, arm; *pous*, foot). A class of Molluscs, with two fleshy ciliated "arms" attached to the sides of the mouth.
- BRACHYURA** (Gr. *brachus*, short; *oura*, tail). The tribe of Crustaceans comprising the Crabs.
- BRANCHIA** (Gr. *bragchia*, the gill of a fish). A breathing-organ adapted for breathing air dissolved in water.
- BRANCHIATE**. Possessing gills.
- BYSSUS** (Gr. *bussos*, flax). The silky threads by which many shell-fish moor themselves to foreign objects.
- CÆCAL** (Lat. *cæcus*, blind). Terminating blindly or in a closed extremity.
- CALYCOPHORIDÆ** (Gr. *kalux*, a cup; *phero*, I carry). An order of *Oceanic Hydrozoa* with bell-shaped swimming-organs.
- CANINE** (Lat. *canis*, a dog). The eye-tooth in the jaw of Mammals, so called because very well developed in Dogs.
- CARNIVORA** (Lat. *caro*, flesh; *voro*, I devour). An order of Mammals.
- CARPUS** (Gr. *karpōs*, the wrist). The small bones which intervene between the forearm and hand.
- CAVICORNIA** (Lat. *cavus*, hollow; *cornu*, horn). The hollow-horned Ruminants, in which the horn consists of a horny sheath round a bony core.
- CEPHALOPODA** (Gr. *kephale*, head; *pous*, foot). The Cuttle-fishes and their allies, in which there is a series of arms ranged round the mouth.
- CETACEA** (Gr. *ketos*, a whale). An order of Mammals.
- CHEIROPTERA** (Gr. *cheir*, hand; *pteron*, wing). An order of Mammals.
- CHELONIA** (Gr. *chelone*, a tortoise). An order of Reptiles.
- CHRYsalis** (Gr. *chrysos*, gold). The motionless pupa of Butterflies and Moths, so called because sometimes exhibiting a golden lustre.
- CILIA** (Lat. *cilium*, an eyelash). Microscopic hair-like filaments, which have the power of lashing backwards and forwards.
- CIRRIPIEDIA** (Lat. *cirrus*, a curl; *pes*, foot). An order of *Crustacea* with curled jointed feet.
- CLAVICLE** (Lat. *clavicula*, a little key). The collar-bone.
- CELENTERATA** (Gr. *koilos*, hollow; *enteron*, intestine). The sub-kingdom comprising the *Actinozoa* and *Hydrozoa*.
- COENOSARC** (Gr. *koinos*, common; *sarx*, flesh). The common fleshy stem which unites together the separate "zooids" of a compound *Actinozoon* or *Hydrozoon*.
- COLEOPTERA** (G. *koleos*, a sheath; *pteron*, wing). The order of the Beetles, in which the front wings are hardened and form protective sheaths for the hind wings.
- CONDYLE** (Gr. *kondulos*, a knuckle). The surface by which one bone is jointed to another. Applied especially to the surfaces by which the head is jointed to the spine.
- CORACOID** (Gr. *korax*, a crow; *eidōs*, form). One of the bones of the shoulder-girdle in Birds, Reptiles, and Monotremes. In most Mammals it forms a mere process of the shoulder-blade, and in man its shape is something like a crow's beak; hence its name.
- CRINOIDEA** (Gr. *krinos*, a lily; *eidōs*, form). An order of *Echinoderms* comprising forms which are usually stalked, and sometimes resemble lilies in shape.
- CROCODILIA** (Gr. *krokodeilos*, a crocodile). An order of Reptiles.
- CRUSTACEA** (Lat. *crusta*, a crust). The Crabs, Lobsters, and the like, in which the body is covered with a hard shell or crust, which is periodically shed.
- CTENOID** (Gr. *kteis*, a comb; *eidōs*, form). Applied to certain scales of Fishes.

CTENOPHORA (Gr. *kteis*, a comb; *phero*, I bear). An order of *Actinozoa* comprising oceanic creatures which swim by means of "ctenophores," or bands of cilia arranged in comb-like plates.

CURSORES (Lat. *curro*, I run). An order of Birds.

CYCLOID (Gr. *kuklos*, a circle; *eidos*, form). Applied to certain scales of Fishes.

CYSTIC (Gr. *kustis*, a bladder). Applied to the young forms of Tape-worms (Bladder-worms).

DECAPODA (Gr. *deka*, ten; *pous*, foot). Applied to certain Crustaceans and Cuttle-fishes.

DIAPHRAGM (Gr. a partition). The "midriff," or the muscle which in *Mammalia* separates the cavity of the chest from that of the abdomen.

DIBRANCHIATA (Gr. *dis*, twice; *bragchia*, gill). The order of *Cephalopoda*, with two gills.

DIGIT (Lat. *digitus*). A finger or toe.

DIGITIGRADE (Lat. *digitus*, a finger; *gradior*, I walk). Walking upon the tips of the toes.

DIPNOI (Gr. *dis*, twice; *pnoē*, breath). An order of Fishes.

DIPTERA (Gr. *dis*, twice; *pteron*, wing). An order of Insects.

DISCOPHORA (Gr. *diskos*, a quoit or round plate; *phero*, I carry). The Jelly-fishes, so called from their form.

DORSAL (Lat. *dorsum*, the back). Connected with the region of the back.

ECHINODERMATA (Gr. *echinos*, a hedgehog; *derma*, skin). The Sea-urchins, Star-fishes, and the like, most of which have spiny skins.

ECHINOIDEA (Gr. *echinos*; and *eidos*, form). The Sea-urchins.

ECTODERM (Gr. *ektos*, outside; *derma*, skin). The outer layer of the body of Coelenterate animals.

EDENTATA (Lat. *e*, without; *dens*, tooth). An order of Mammals.

ELASMOBRANCHII (Gr. *elasma*, a thin plate; *bragchia*, gill). An order of Fishes.

ENDODERM (Gr. *endon*, within; *derma*, skin). The inner layer of the body of Coelenterate animals.

ERRANTIA (Lat. *erro*, I wander). An order of Ringed worms (*Annelida*).

FIBULA (Lat. a brooch). The outermost of the two bones of the leg in the higher Vertebrates.

FORAMINIFERA (Lat. *foramen*, a hole; *fero*, I carry). An order of Protozoa, usually with perforated shells.

FURCULUM (Lat. diminutive of *furca*, a fork). The V-shaped bone or "merry-thought" of Birds, formed by the united clavicles.

GANOID (Gr. *ganos*, splendour; *eidos*, form). Applied to certain of the scales of Fishes.

GANOIDEI. An order of Fishes with ganoid scales.

GASTEROPODA (Gr. *gaster*, belly; *pous*, foot). A class of Molluscs in which locomotion is usually effected by creeping about on a flattened "foot."

GONOPHORE (Gr. *gonos*, offspring; *phero*, I bear). The reproductive buds of the *Hydrozoa*.

GRALLATORES (Lat. *gralla*, stilts). The order of the Wading Birds.

GREGARINIDÆ (Lat. *gregarius*, occurring in numbers together). A class of the *Protozoa*.

HEMIPTERA (Gr. *hemi*, half; *pteron*, wing). An order of Insects.

HETEROCERICAL (Gr. *heteros*, diverse; *kerkos*, tail). Applied to the tail of Fishes when it is unequally lobed.

- HETEROPODA** (Gr. *heteros*, diverse; *pous*, foot). An order of Gasteropodous Molluscs.
- HIRUDINEA** (Lat. *hirudo*, a horse-leech). The order of the Leeches.
- HOMOCERCAL** (Gr. *homos*, same; *kerkos*, tail). Applied to the tail of Fishes when it is equally lobed.
- HYDRA** (Gr. *hudra*, a water-serpent). The generic name of the Fresh-water Polypes.
- HYDROIDA** (Gr. *hudra*; *eidos*, form). The sub-class of the Hydroid Zoophytes.
- HYDROTHECA** (Gr. *hudra*; *theke*, case). The little cups in which are contained the polypites of certain of the Hydroid Zoophytes (*Sertularida*).
- HYDROZOA** (Gr. *hudra*; *zoön*, animal). The class of Coelenterate animals comprising creatures constructed after the type of the *Hydra*.
- HYMENOPTERA** (Gr. *humen*, a membrane; *pteron*, a wing). An order of Insects.
- HYRACOIDEA** (Gr. *hurax*, a shrew; *eidos*, form). An order of Mammals.
- IMAGO** (Lat. an image or apparition). The perfect Insect after it has passed through all its metamorphoses.
- INCISORS** (Lat. *incido*, I cut). The cutting-teeth fixed in the front of the upper jaw, and the corresponding teeth in the lower jaw of the Mammalia.
- INFUSORIA** (Lat. *infusum*, an infusion). A class of the *Protozoa*, so called from their frequent occurrence in organic infusions.
- INSECTA** (Lat. *inseco*, I cut into). The class of the true Insects.
- INSECTIVORA** (Lat. *insectum*, an insect; *voro*, I devour). An order of Mammals.
- INVERTEBRATA** (Lat. *in*, without; *vertebra*, a bone of the back). Animals without a backbone.
- ISOPODA** (Gr. *isos*, equal; *pous*, foot). An order of *Crustacea* comprising the Wood-lice and their allies.
- LACERTILIA** (Lat. *lacerta*, a lizard). An order of Reptiles.
- LAMELLIBRANCHIATA** (Lat. *lamella*, a plate; Gr. *bragchia*, gill). The Bivalve Shell-fish.
- LARVA** (Lat. a mask). The insect in its first stage after being hatched, when it is usually very unlike the adult.
- LEPIDOPTERA** (Gr. *lepis*, a scale; *pteron*, a wing). The order of Insects comprising the Butterflies and Moths.
- LUCERNARIDA** (Lat. *lucerna*, a lamp). A division of the *Hydrozoa*.
- MACRURA** (Gr. *makros*, long; *oura*, tail). The tribe of Crustaceans comprising the Lobsters and their allies.
- MADREPORIFORM**. Perforated by small holes like a Coral (or *Madrepore*).
- MAMMALIA** (Lat. *mamma*, the breast). The class of Vertebrate animals which suckle their young.
- MARSIPOBRANCHII** (Gr. *marsipos*, a pouch; *bragchia*, gill). An order of Fishes.
- MARSUPIALIA** (Lat. *marsupium*, a pouch). An order of Mammals.
- MEDUSÆ**. A group of *Hydrozoa* comprising the Jelly-fishes, so called because of the resemblance of their tentacles to the snaky hair of the Medusa.
- MEDUSIFORM**. Resembling a Jelly-fish in shape.
- MESENTERIES** (Gr. *mesos*, intermediate; *enteron*, intestine). The membrane by which the intestine is attached to the wall of the abdomen. In a restricted sense, the vertical plates which divide the body-cavity of a Sea-anemone into chambers.
- METACARPUS** (Gr. *meta*, after; *karpus*, wrist). The bones which form the "root of the hand," and intervene between the wrist and the fingers.
- METAMORPHOSIS** (Gr. *meta*, denoting change; *morphe*, shape). The

changes of form which certain animals undergo in passing from their younger to their fully-developed condition.

METATARSUS (Gr. *meta*, after; *tarsos*, instep). The bones which intervene between the instep and the toes in the higher Vertebrates.

MOLARS (Lat. *mola*, a mill). The "grinders" in man; or the teeth in Mammals which are not preceded by milk-teeth.

MOLLUSCA (Lat. *mollis*, soft). The sub-kingdom comprising the true Shell-fish, the Sea-mosses, the Sea-squirts, and the Lamp-shells.

MOLLUSCOIDA (*Mollusca*; and Gr. *eidos*, form). The lower division of the sub-kingdom *Mollusca*.

MONOTREMATA (Gr. *monos*, single; *trema*, aperture). An order of Mammals.

MYRIAPODA (Gr. *myrios*, countless; *pous*, foot). The class of Articulate animals comprising the Centipedes and their allies.

NATATORES (Lat. *nare*, to swim). The order of the Swimming Birds.

NEMATODA (Gr. *nema*, thread; *eidos*, form). A division of the *Scolecida*.

NEUROPTERA (Gr. *neuron*, a nerve; *pteron*, a wing). An order of Insects.

NOTOCHORD (Gr. *notos*, the back; *chordē*, a string). A cellular rod which is developed in the embryo of Vertebrates immediately beneath the spinal cord, and is usually replaced in the adult by the vertebral column.

NUDIBRANCHIATA (Lat. *nudus*, naked; Gr. *bragchia*, gill). An order of Gasteropodous Molluscs.

OCTOPODA (Gr. *okto*, eight; *pous*, foot). A tribe of Cuttle-fishes with eight arms round the head.

ODONTOPHORE (Gr. *odous*, tooth; *phero*, I carry). The "tongue" or masticating apparatus of the *Gasteropoda*, *Pteropoda*, and *Cephalopoda*.

OLIGOCHÆTA (Gr. *oligos*, few; *chaitē*, bristle). The order of Annelides comprising the Earth-worms.

OPHIDIA (Gr. *ophis*, a serpent). An order of Reptiles.

OPHIOMORPHA (Gr. *ophis*, a serpent; *morphe*, sharpe). An order of *Amphibia*.

OPHIUROIDEA (Gr. *ophis*, a serpent; *oura*, tail). An order of Echinoderms (Sand-stars, &c.)

ORTHOPTERA (Gr. *orthos*, straight; *pteron*, wing). An order of Insects.

PECTORAL (Lat. *pectus*, the breast). Connected with the chest.

PEDIPALPI (Lat. *pes*, foot; *palpo*, I feel). An order of *Arachnida* (Scorpions, &c.)

PERISSODACTYLA (Gr. *perissos*, uneven; *daktulos*, finger). The Hoofed Quadrupeds (*Ungulata*) in which the toes are uneven in number (one or three).

PHALANGES (Gr. *phalanx*, a row). The small bones of the fingers and toes.

PHARYNGOBRANCHII (Gr. *pharugx*, the pharynx; *bragchia*, gill). An order of Fishes.

PHARYNX (Gr. *pharugx*). The upper part of the gullet.

PHYSOPHORIDÆ (Gr. *phusa*, bellows or air-bladder; *phero*, I carry). An order of Oceanic *Hydrozoa*.

PINNIGRADA (Lat. *pinna*, a feather; *gradior*, I walk). Applied to the Seals and Walruses, in which the limbs are converted into swimming-paddles.

PISCES (Lat. *piscis*, a fish). The class of the Fishes.

PLACOID (Gr. *plax*, a plate; *eidos*, form). Applied to certain scales of Fishes.

PLANARIDA (Gr. *plane*, wandering). A group of the *Scolecida*.

PLANTIGRADE (Lat. *planta*, the sole of the foot; *gradior*, I walk). Applying the sole of the foot to the ground in walking.

POLYPE (Gr. *polus*, many; *pous*, foot). Restricted to the single individual of a simple *Actinozoön*, or to the separate zoöids of a compound *Actinozoön*.

POLYPIDE. The separate zoöid of a *Polyzoön*.

POLYPITE. The separate zoöid of a *Hydrozoön*.

POLYZOA (Gr. *polus*, many; *zoön*, animal). The Sea-mosses and Sea-mats, an order of the *Mollusca*.

PROBOSCIDEA (Lat. *proboscis*, the snout). An order of Mammals (Elephants).

PROTOZOA (Gr. *protos*, first; *zoön*, animal). The lowest division of the animal kingdom.

PSEUDOHÆMAL (Gr. *pseudos*, falsity, hence false; *haima*, blood). Applied to a peculiar system of vessels found in the Annelides.

PSEUDOPODIA (Gr. *pseudos*, false; *pous*, foot). The extemporised feet of the *Rhizopoda*.

PTEROPODA (Gr. *pteron*, wing; *pous*, foot). A class of *Mollusca*.

PULMONARY (Lat. *pulmo*, a lung). Connected with the lungs.

QUADRUMANA (Lat. *quatuor*, four; *manus*, hand). An order of Mammals (Monkeys, &c.)

RADIOLARIA (Lat. *radius*, a ray). An order of *Rhizopoda*.

RADIUS. The innermost of the two bones of the forearm of the higher Vertebrates.

RAPTORES (Lat. *raptō*, I plunder). The order of the Birds of Prey.

RASORES (Lat. *rado*, I scrape or scratch). The order of the Scratching Birds (Fowls, Pigeons, &c.)

REPTILIA (Lat. *repto*, I crawl). The class of Vertebrates comprising the true Reptiles.

RHIZOPODA (Gr. *rhiza*, root; *pous*, foot). A division of the *Protozoa*.

RODENTIA (Lat. *rodo*, I gnaw). An order of Mammals.

ROTIFERA (Lat. *rota*, a wheel; *fero*, I carry). A class of the *Scolecida* (Wheel-animalcules).

RUMINANTIA (Lat. *rumino*, I chew the cud). A group of the Hoofed Quadrupeds.

SARCODE (Gr. *sarx*, flesh; *eidos*, form). The jelly-like substance composing the body in the *Protozoa*.

SCANSORES (Lat. *scando*, I climb). The order of the Climbing Birds (Parrots, &c.)

SCOLECIDA (Gr. *skolex*, a worm). A division of the *Annuloida*.

SERTULARIDA (Lat. *sertum*, a wreath). An order of the Hydroid Zoophytes.

SIPHONOPHORA (Gr. *siphon*, a tube; *phero*, I carry). A sub-class of the *Hydrozoa*.

SIRENIA (Gr. *seiren*, a mermaid). An order of Mammals (Dugongs and Manatees).

SOMATIC (Gr. *soma*, body). Connected with the body.

SPICULA (Lat. *spiculum*, a point). Pointed needle-shaped bodies.

SPONGIDA (Gr. *spoggos*, a sponge). A division of the *Protozoa* (Sponges).

STERNUM (Gr. *sternon*). The breast-bone.

TÆNIADA (Gr. *tainia*, a ribbon). The order of the Tape-worms.

TARSUS (Gr. *tarsos*, the flat of the foot). The small bones which form the ankle (or instep of man).

TELEOSTEI (Gr. *teleios*, perfect; *osteon*, bone). The order of the Bony Fishes.

TEST (Lat. *testa*, a shell). The shell of the Molluscs, Sea-urchins, &c.

TETRABRANCHIATA (Gr. *tetra*, four; *bragchia*, gill). The order of *Cephalopoda* with four gills.

THORAX (Gr. a breast-plate). The chest.

TIBIA (Lat. a flute). The shin-bone, or innermost of the two bones of the leg in the higher Vertebrates.

TRACHEA (Gr. *tracheia*, the rough windpipe). In air-breathing Vertebrates, the tube which conveys the air to the lungs. In Insects, Myriapods, and Spiders, the air-tubes which ramify through the body.

TREMATODA (Gr. *trema*, a pore or hole). An order of the *Scolecida*.

TUBICOLA (Lat. *tuba*, a tube; *colo*, I inhabit). An order of the *Annelida* (Tube-worms).

TUNICATA (Lat. *tunica*, a cloak). The Sea-squirts, a class of the Mollusca.

ULNA (Gr. *olené*, the elbow). The outermost of the two bones of the forearm in the higher Vertebrates.

UMBO (Lat. the boss of a shield). The beak of a bivalve shell.

UNGULATA (Lat. *ungula*, a hoof). The order of the Mammals comprising the Hoofed Quadrupeds.

URODELA (Gr. *oura*, tail; *delos*, visible). The order of the Tailed Amphibians (Newts, &c.)

VENTRAL (Lat. *venter*, the belly). Relating to the lower surface of the body.

VERTEBRA (Lat. *verto*, I turn). One of the bones of the spinal column or backbone.

VERTEBRATA. The sub-kingdom comprising animals, almost all of which have a more or less well-developed vertebral column.

XIPHOSURA (Gr. *xiphos*, sword; *oura*, tail). An order of the *Crustacea* (King-Crabs).

ZOÖID (Gr. *zoön*, animal; *eidos*, form). The more or less completely independent being, produced by budding or fission from a primitive organism.

ZOOPHYTE (Gr. *zoön*, animal; *phuton*, plant). Loosely applied to many plant-like animals, such as Sponges, Corals, Sea-anemones, Sea-firs, Sea-mats, &c.

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